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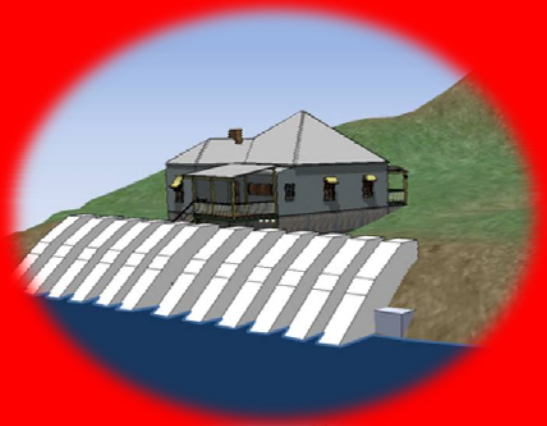
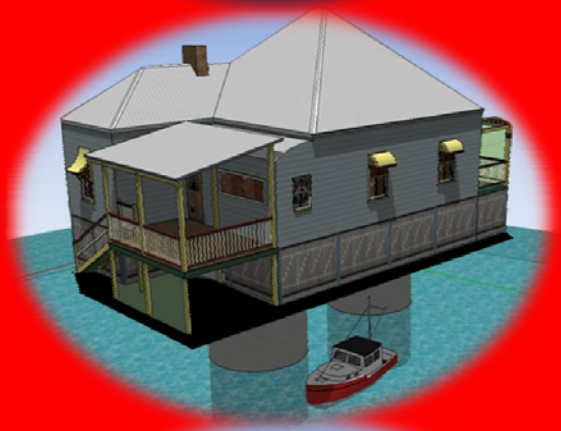
South East Queensland
Climate Adaptation Research Initiative
(SEQ CARI)





Adaptation Options for Human Settlements in South East Queensland

Main Report

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A report for the South East Queensland Climate Adaptation Research Initiative

May 2012

This report, *Adaptation Options for Human Settlements in South East Queensland*, is part of the South East Queensland Climate Adaptation Research Initiative (SEQ CARI), a partnership between the Queensland and Australian Governments, the CSIRO Climate Adaptation National Research Flagship, Griffith University, University of the Sunshine Coast and The University of Queensland.

South East Queensland (SEQ) is particularly vulnerable to climate change because of its growing population and coastal location. Human settlements, infrastructure, unique ecosystems, and primary industries all face threats from more extreme weather events, increased temperatures and altered rainfall patterns as a result of increased greenhouse gas emissions. Despite these risks and challenges, climate change may also bring some economic and social opportunities.

SEQ CARI aims to provide research knowledge to enable the region to adapt and prepare for the impacts of climate change. It will develop practical and cost-effective adaptation strategies to assist decision makers in government, industry and the community. The initiative is the first comprehensive regional study on climate change adaptation undertaken in Australia and one of only a few worldwide. It is exploring both vulnerabilities and adaptation options in response to climate change so that our prosperous regional economy, environment and lifestyles can be maintained into the future.

For more information about this and other projects in the South East Queensland Climate Adaptation Research Initiative (SEQ CARI) visit: www.csiro.au/partnerships/seqcari.html

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Queensland Department of Environment and Resource Management
Queensland Department of Local Government and Planning
Queensland Department of Transport and Main Roads
Queensland Health
Australian Coastal Society
Australian Institute of Emergency Services
Australian Red Cross (Queensland)
GECKO – Gold Coast and Hinterland Environment Council
Gold Coast Public Hospital Unit
International Water Centre
Local Government Association of Queensland
Property Council of Australia (Queensland)
Queensland Coastal Council Group
Queensland Council of Social Service
Queensland Police Service
Queensland Rural Fire Service
Saint Vincent de Paul
SEQ Catchments
Sunshine Coast Public Hospital Unit
Surf Life Saving Australia
State Emergency Service
Urban Development Institute of Australia (Queensland Branch)

[1] Names and titles of State government agencies that were active at the time of the research have been maintained for the purposes of this report.

EXECUTIVE SUMMARY

This report documents the final phase of the Human Settlements component of the of the broader three-year integrated multi-sectoral study of climate change adaptation options for South East Queensland (SEQ) – the South East Queensland Climate Adaptation Research Initiative (SEQ CARI). It builds on the study's previous seven phases which involved: the identification and preliminary desktop analysis of key issues for SEQs human settlements; the selection, definition and description of appropriate case studies for closer examination of climate change; comprehensive literature reviews and document analyses in all five human settlement sectors; the development of preliminary adaptation options for the region and its six human settlement types; testing of preliminary adaptation options through a scenario planning process; and supplementary testing through further stakeholder engagement involving interviews, workshops and surveys. These preceding phases led to, and informed, the development of specific sectoral and cross sectoral adaptation options. This phase involved a significant cross sectoral Human Settlements team effort and investment to synthesise the research findings through a series of team retreats and internal workshops.

All the Project Brief's scope and intended outputs have been met along with the series of Human Settlements research questions. The three overarching principal project intentions that were relevant to the Human Settlements component have been addressed and the final suite of adaptation options contains adaptation programs that satisfy these applied requirements. Likewise, the eight principal research questions, along with the sector specific research questions have been addressed. The sectoral issues and trends previously identified in the first phase of the study have been addressed by the 21 policies, 95 programs, and 498 actions that have been developed across the Human Settlements component.

This study has been the first comprehensive regional study of climate change adaptation in Australia, and one of just a few worldwide. Its comprehensive nature is borne out through its coverage of the five principal Human Settlements sectors of: urban planning and management; coastal management; physical infrastructure related to local government; emergency management; and human health.

It is critical that relevant combinations of the proposed adaptation options, in the form of policies, programs and actions for each of the five sectors, are implemented to minimise SEQ's vulnerability to future climate change impacts, including natural hazards. Failure to implement the appropriate adaptation options will continue to place the region, its settlements and population at risk. Furthermore, it could also lead to significant economic, social and environmental losses with further consequences for both the region's liveability and sustainability.

The lack of scientific knowledge, the uncertainty associated with climate science and future risks from natural hazards, and the political sensitivities in dealing with climate change should not continue as a barrier to effective adaptation and delay the implementation of robust measures of adaption action to climate change with respect to human settlements which are characterised by major investments, long planning timelines and potentially vulnerable communities. This study has demonstrated that

these barriers can be overcome through research strategies involving hypothetical case studies operating through a comprehensive scenario planning process. Participants involved in the extensive stakeholder engagement achieved in this human settlements study have also had opportunities to extend and improve their respective individual and institutional adaptive capacity to address climate change adaptation.

Whilst all of the adaptation options have been developed to address climate change, many of the recommended adaptation options represent 'no-regrets' options where their implementation would contribute to improvements in the community, the landscape and society generally, regardless of climate change impacts. Thus it will be essential to identify particular 'no-regret' options (on a case by case basis), relevant to the particular case and circumstance when advocating for the funding of adaptation option packages.

Underpinning the whole Human Settlements approach to climate change adaptation is the notion of informed and confident political, private sector and community leadership, supported by an informed, engaged and prepared community that are reinforced through continuous awareness, training, education and capacity building programs that operate in a process of full stakeholder engagement leading to mutually agreed actions. These initiatives are occurring in a process characterised by holistic and proactive responses and integrated and coordinated action, operating within mainstreamed adaptive management practices where a regional perspective cascades to local approaches which incorporate targeted responses. All of these initiatives are supported by ongoing research.

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GLOSSARY

Notes:
1. This glossary defines some specific terms as the lead authors intend them to be interpreted in the context of this Report.
2. Some definitions are taken from IPCC (2007), UNFCCC (1992), Climate Change Risks to Australia's Coast (2007), Garnaut Climate Change Review (2008) and UKCIP Technical Report (Climate adaptation: Risk, uncertainty and decision-making - 2003).

Acronym or Abbreviation	Term	Definition
-	Adaptability	See adaptive capacity.
-	Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
-	Adaptive capacity	How well equipped a system is to adjust to climate change to reduce potential damage, to take advantage of opportunities, or to cope with the consequences.
-	Adaptation costs	Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.
AHP	Analytic Hierarchy Process	A method designed to help in prioritising very complex decision alternatives involving multiple stakeholders and multiple goals.
-	Anticipatory adaptation/ proactive adaptation	Adaptation that takes place before impacts of climate change are observed.
-	Autonomous adaptation/ spontaneous adaptation	Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
AM	Asset Management	The integrated, multi-disciplinary set of strategies in sustaining public infrastructure assets such as water treatment facilities, sewer lines, roads, utility grids, bridges, and railways.
-	Buddy system/ Climate buddies	Aim to empower people to include climate change considerations into every decision they make. Focusing on live interaction with groups of people, for-profits, spiritual groups, public and academia. Non-profit.
-	Building code/control	Rules that specify the acceptable level of safety for constructed objects such as buildings and other structures.
-	Buy-back/ voluntary purchase schemes	Property owner willingly sells property, usually to the local or state government.
-	Capacity building/capacity development	Conceptual approach to development that focuses on understanding the obstacles that inhibit people, governments, international organisations and non-governmental organisations from realising their developmental goals while enhancing the abilities that will allow them to achieve measurable and sustainable results.
-	Climate	Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization.
CCA	Climate change	Response to climate change that seeks to reduce the vulnerability of

Acronym or Abbreviation	Term	Definition
	adaptation/ adaptation to global warming	natural and human systems to climate change effects.
CC	Climate change/ changing climate	Any change in climate over time, whether due to natural variability or as a result of human activity. (IPCC) OR A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (UNFCCC)
-	Climate risks	Resulting from climate change and affecting natural and human systems and regions.
-	Climate prediction	A climate prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate in the future, e.g. at seasonal, inter-annual or long-term time scales.
-	Climate projection	The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinguished from climate predictions, in that the former critically depend on the emissions/ concentration/radiative forcing scenario used, and therefore on highly uncertain assumptions of future socio-economic and technological development.
-	Climate (change) scenario	A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A 'climate change scenario' is the difference between a climate scenario and the current climate.
CM	Coastal management	Sector of Human Settlements component in SEQ CARI.
-	Communication	To convey information to stakeholders and communities.
-	Community	Social unit that is non government.
CSIRO	Commonwealth Scientific and Industrial Research Organisation	
-	Consultation	A process by which the communities and stakeholders input on matters affecting them is sought.
COAG	Council of Australian Governments	
-	Decentralisation	Spread of power away from the centre to local branches or governments.
-	Defend	A form of adaptation which defends against the impact of climate change.
-	Devolution	Granting of powers from the central government of state to government at regional or local level.
DEM	Digital Elevation Model	
DM	Disaster	Organisation and management of resources and responsibilities for dealing

Acronym or Abbreviation	Term	Definition
	management	with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.
-	Disaster preparedness	Process of ensuring that an organisation (1) has complied with the preventive measures, (2) is in a state of readiness to contain the effects of a forecasted disastrous event to minimize loss of life, injury, and damage to property, (3) can provide rescue, relief, rehabilitation, and other services in the aftermath of the disaster, and (4) has the capability and resources to continue to sustain its essential functions without being overwhelmed by the demand placed on them.
DRR	Disaster Risk Reduction	Action taken to reduce the risk of disasters and the adverse impacts of climate change/natural hazards, through systematic efforts to analyse and manage the causes of disasters, including through avoidance of hazards, reduced social and economic vulnerability to hazards, and improved preparedness for adverse events.
-	Education	Capacity building, training, awareness, knowledge sharing, resources to support capacity.
EMQ	Emergency Management Queensland	
EM	Emergency management	Sector of Human Settlements component in SEQ CARI.
-	Essential infrastructure	Critical physical infrastructure for the functioning of emergency services and lifeline of the community (i.e. roads, bridges, stormwater networks, electricity).
-	Extreme events/ climate extremes	An event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10^{th} or 90^{th} percentile. By definition, the characteristics of what is called 'extreme weather' may vary from place to place. Extreme weather events may typically include floods and droughts.
-	Flood control	Hard defence against flooding.
-	Flood proof/ watertight/ flood resistant	Any combination of structural and non-structural additions, changes, or adjustments to structures which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and their contents.
-	Forum	Meeting/ workshop with the intention of sharing knowledge.
-	Gentrification	Change in social demographics.
GIS	Geographic Information Systems	
-	Hot spot	The most responsive regions to projected climatic variable change under different emission scenarios.
HH	Human health	Sector of Human Settlements component in SEQ CARI.
HS	Human Settlements	Human Settlements component in SEQ CARI.
-	Impacts	The effects of climate change on natural and human systems.
-	Impacts (potential)	All impacts that may occur given a projected change in climate, without considering adaptation.

Acronym or Abbreviation	Term	Definition
-	Impacts (residual)	The impacts of climate change that would occur after adaptation.
-	Incentive	Social/financial incentive which aims to add to success of addressing climate change.
-	Infrastructure	The basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of an organisation, city or nation.
-	Land reclamation/ reclamation ground	Process of creating new land out of land that has been removed by sea or rivers.
-	Land swap/ exchange	A program allowing property owner to 'swap' their land for part of the newly purchased council land. This process can be voluntary or compulsory.
-	Land use change/conversion	Where land use and its practices are contributing to declining land condition, then the land use is changed to more appropriate practices.
-	Land/ property resumption	Property required by government for infrastructure projects.
-	Mitigation	An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.
MCA	Multi-criteria analysis	A structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives.
MCDA	Multi-criteria decision analysis	A form of MCA that is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option.
-	Natural hazard	Bushfires, heatwaves, coastal erosion, flooding, drought, severe storm events.
NGO	Non-government organisation	Group of leaders from across the community sector, including unions, social services, environment groups and local government.
PI	Physical infrastructure	Sector of Human Settlements component in SEQ CARI.
-	Planned adaptation	Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.
PPRR	Prevention, preparedness, response and recovery	The four phases of disaster management.
PRG	Project Reference Group	Key stakeholder group assembled to review and provide advice to Human Settlements component
-	Regulatory	Administrative legislation that constitutes or constrains rights and allocates responsibilities.
-	Relocation	Communities and services relocation as an adaptive response.
-	Resilience	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.
-	Retreat	Relocation to place which is away from climate change threats.
-	Retrofitting	Addition of new technology or features to an older system.

Acronym or Abbreviation	Term	Definition
-	Risk	Combination of the probability of an event and its consequences.
QCOSS	Queensland Council of Social Service	
RM	Road map	Description of polices, programs and actions recommended for adaptation.
-	Rolling easement	Make no effort to restrict land use but prevent shore protection of some coastal lands either through regulation or by transferring any right to hold back the sea from owners inclined to do so to organisations that would not.
RQ	Research question	
-	Runoff	That part of precipitation that does not evaporate and is not transpired.
SLR	Sea level rise	An increase in the mean level of the ocean. Eustatic sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea-level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall.
-	Sea wall	A human-made wall or embankment along a shore to prevent wave erosion.
-	Shelter	Evacuation centre/ public cool spaces away from climate threats.
SEQ	Southeast Queensland	
SEQ CARI	Southeast Queensland Climate Adaptation Research Initiative	A three year research program which will assess south-east Queensland's vulnerability to climate change, and develop practical, cost-effective strategies to help the region adapt.
-	Stakeholders	People, groups, organisations, as well as governments and communities, that have a direct or indirect stake in climate change.
SES	State Emergency Services	
-	Socioeconomic Status	A measure of an individual (or family)'s status based on the combined measure of income, education level, occupation and economic and social status in the community.
SPP	State Planning Policy	
-	Submergence	Dry land becoming wetland or open water, whether through actual submergence or shoreline erosion.
-	Surface runoff	The water that travels over the land surface to the nearest surface stream; runoff of a drainage basin that has not passed beneath the surface since precipitation.
TDR	Transfer of development rights	Program for exchange of zoning privileges from areas with low population needs, such as farmland, to areas of high population needs.
UPM	Urban planning and management	Sector of Human Settlements component in SEQ CARI.
-	Uncertainty	An expression of the degree to which a value (e.g. the future state of the climate system) is unknown.
-	Vulnerability	Vulnerability is the degree to which a system is susceptible to, and unable

Acronym or Abbreviation	Term	Definition
		to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.
VA	Vulnerability assessment	The process of identifying, quantifying, and prioritising (or ranking) the vulnerabilities in a system.

PART I

1.0 INTRODUCTION

This report documents the findings from the final phase of research completed by the Human Settlements component of the broader three-year integrated multi-sectoral study of climate change adaptation options for South East Queensland (SEQ) – the South East Queensland Climate Adaptation Research Initiative (SEQ CARI). The overarching SEQ CARI goal was:

> "*to develop practical and cost-effective climate adaptation strategies for decision-makers in government, industry and the community*"

To this end the project has sought to examine the vulnerability and adaptation in key sectors that align with the priority sectors identified in the Queensland Government's ClimateSmart Adaptation Strategy (Queensland Government 2007). One of the Strategy's four priority sectors was identified as: human settlements; infrastructure; emergency services; and health.

This final phase builds on the outputs of the previous phases which involved: the identification and preliminary desktop analysis of key issues relevant to human settlements in SEQ; the selection, definition and description of appropriate case studies for closer examination of climate change; comprehensive literature reviews and document analyses in all five Human Settlements sectors; the development of preliminary adaptation options for the region and its six selected human settlement types; the testing of the preliminary adaptation options through a scenario planning process; and supplementary testing through further stakeholder engagement involving interviews, workshops and surveys. These preceding phases led to, and informed, the development and internal testing of specific sectoral and cross sectoral adaptation options. This phase involved a significant cross sectoral team effort amongst the Human Settlements researchers which included the disciplines of: urban and regional planning; environmental planning; coastal engineering; civil engineering; sociology; social science; economics and geography. This part of the Human Settlements collaborative research effort included a significant investment in the synthesis of research findings and outputs and involved a series of team retreats and workshops to expedite this process.

This report describes and discusses the approach adopted to investigate and develop adaptation options for climate change in SEQ with respect to the five sectors of Human Settlements. It further discusses the testing of these adaptation options in terms of their robustness, appropriateness and internal compatibility within the Human Settlements paradigm. The full suite of sectoral and cross sectoral adaptation options are outlined in detailed in the accompanying Supplementary Report[2]. Summaries of these adaptation options are contained in the subsequent

[2] See: Darryl Low Choy, Silvia Serrao-Neumann, Florence Crick, Gemma Schuch, Marcello Sanò, Rudi van Staden, Oz Sahin, Ben Harman and Scott Baum, 2012, *Adaptation Options for Human Settlements in South East*

chapters of this report. The principal milestone reports of the Human Settlements research which culminates with this report are:

1. McDonald J, Baum S, Crick F, Czarnecki J, Field G, Low Choy D, Mustelin J, Sanò M & Serrao-Neumann S (2010) ***Climate change adaptation in South East Queensland human settlements: Issues and context***, unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.
2. Low Choy D, Baum S, Serrao-Neumann S, Crick F, Sanò M & Harman B (2010) ***Climate Change Vulnerability in South East Queensland: A Spatial and Sectoral Assessment***, unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.
3. Low Choy D, Serrao-Neumann S, Baum S, Crick F, Sanò M, van Staden R, Harman B, Schuch G & Sharma V (2011) ***Hypothetical Case Study Elaboration***, unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.
4. Low Choy D, Serrao-Neumann S, Crick F, Schuch G, Sanò M, van Staden R, Sahin O, Harman B & Baum S (2012) ***Scenario Planning for Climate Change Adaptation***, unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.

The members of the Human Settlements team who completed the research and had the responsibility for the adaptation options presented in this report and its accompanying report are listed in Appendix A.

2.0 THE HUMAN SETTLEMENTS COMPONENT

The Human Settlements component includes the interrelated sectors of: urban planning and management; coastal management; physical infrastructure related to local government; emergency management; and human health. Within the context of climate change adaptation, these respective sectors were defined as:

> **Urban planning and management (UPM)** involves a planning process, largely in the hands of state and local governments that encompasses regional and local statutory and non-statutory planning instruments such as policies, strategies, programs and plans to configure the form and function of cities, towns and regions. Urban planning and management must attend to the task of adapting new developments to the predicted impacts of climate change and also have regard to the redevelopment and/or retrofitting of existing settlements.
>
> **Coastal management (CM)** is the combination of human processes and actions to manage the interaction between human settlements and natural processes within the coastal zone. These may include the dynamics of tidal waters, biogeochemical cycles and ecosystems functions, interacting with human settlements in a number of ways. Whilst considering both the current

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Queensland – Supplementary Report, unpublished report for the South East Queensland Climate Adaptation Research Initiative, Griffith University.

situation and future sea level rise scenarios, coastal management seeks to reduce the risk to human settlements by identifying adaptation options that manage storm tide inundation and erosion, while maintaining the natural functions of coastal ecosystems.

Physical infrastructures (PI) are public artefacts that are essential to sustain social and economic activities by providing communities with the ability to move goods, people, and information safely and reliably. Infrastructures are vulnerable to increased temperatures, rainfall and flooding and even modest disruptions can have significant effects on daily life, and any systematic change in the frequency or intensity of those disruptions could have profound consequences for economic and human well-being. Whilst local governments, in particular, have traditionally made significant long term investments in infrastructure they must now continue to do so with the added requirement to adapt to cope with the impact of climate change to reduce the vulnerabilities of their infrastructure investments.

Emergency management (EM) is a community's frontline in dealing with disasters, particularly those arising from the advent of natural hazards and extreme weather events. Contemporary emergency management approaches are founded on a comprehensive and linked disaster management system that plans across the four phases of prevention, preparedness, response and recovery (PPRR). Hence, emergency management systems and agencies can play a key role in reducing human settlements vulnerability to extreme weather events and climate change.

Human health (HH) in urban environments comprises a wide breadth of environmental, social and economic determinants where the actual health consequences of climate change are strongly influenced by the socioeconomic context. Hence, the impact of climate on human health can be both direct (e.g. thermal stress, flood and fire causing injury and death) and indirect, through disease (e.g. Ross River fever), contamination (e.g. food and water supply) and environmental degradation, such as poor air quality and loss of crop land. The extent of health impacts from climate change depends to a large extent on arrangements for climate adaptation and the adaptive capacity of health institutions as well as communities and the private sector.

The Human Settlements component and its five principal sectors have been aligned to address a series of **research questions (RQs)**, namely:

1. What adaptation actions (including human, institutional and organisational capacity) are currently employed to reduce the effects of climate change on human health, urban form and infrastructure, environmental and urban amenity and public safety?
2. What are major obstacles/barriers to effective adaptation in human settlements, encompassing urban planning, coastal management, emergency management and human health sectors, and how can these be overcome?
3. What are the current institutional, policy and regulatory arrangements and responsibilities for the management of human settlements in SEQ, and are they able to deal with increasing demands imposed by a changing climate?

4. What links between sectors must be understood in order to develop integrated and holistic cross-sectoral adaptation strategies for human settlements in SEQ? Are current arrangements for the coordination of adaptation decision-making across sectors best designed to support successful collective action?
5. What initiatives can enhance communities' ability to deal with climate change and expanding and changing risks in the future?
6. How can the role of the private sector be enhanced to promote adaptation?
7. Which tools, strategies, models and mechanisms should each sector utilise to adapt to climate change in urban landscapes?
8. How can lessons learned about effective climate change adaptation at the local level be transferred to other locations and contexts?

Within each sector of the Human Settlements component, a number of specific research questions were developed – these are reviewed in each respective sector narrative (see Chapter 10).

3.0 METHODOLOGY

From the outset, the SEQ CARI project was overarched by a set of stated project intentions which directed the research strategy and the specific methodologies and techniques that were employed to address the research questions. These intentions, outlined in the Project Brief, were of a pragmatic nature and consequently gave rise to an applied research approach. The project intentions that had specific relevance to the Human Settlements component sought to ensure that:

- Urban planners (*are*) provided with the information, capacity and tools to incorporate climate change risk into regional and local government planning and development;
- Design criteria needed for critical infrastructure such as roads, bridges, buildings, stormwater and sewerage systems under altered climate and changed weather extremes … (*are researched*); and
- Climate change impacts (*can be*) incorporated into public health and natural disaster response management, particularly for flooding, cyclones, bushfires, storm surges.

The research project was specifically directed to the SEQ region due to the earlier recognition of this region as one of six climate change 'vulnerability hotspots' in Australia (Hennessy et al 2007). The region is particularly vulnerable because of its coastal location and the distribution and location of its rapidly growing population.

The project adopted a research approach that took both a systems view of the whole region and focused on key sectors within the SEQ region. For the purposes of this study the SEQ region that was researched coincided with the boundaries of the state government's formal statutory SEQ Regional Plan (Department of Infrastructure and Planning 2009) which overarches all statutory planning at state and local government levels and the private sector.

To this end, the intended scope of the Human Settlements component research and the nature of its outputs were defined in the Project Brief as a sectoral analysis to:

1. Develop a comprehensive vulnerability assessment for SEQ by:
    a. Conducting a spatial assessment of the vulnerability of human settlements in SEQ; and
    b. Undertaking detailed case studies of 4/5 locations that represent key issues for the planning and implementation of adaptation measures in the region; then
2. Develop adaptation options (including the temporal dimensions of climate impacts).

The methodological response comprised an eight phase approach to address these specific project requirements and intentions (see Figure 1: SEQ CARI Human Settlements component's Phased Methodology). The eight distinct phases which the Human Settlements team stepped through over the three year project time frame included:

1. Issues & context analysis (with ongoing sectoral research to identify the range of technical, design, planning and management adaptation options);
2. Social vulnerability assessment;
3. Development and analysis of the hypothetical region of *Lilliput* and its human settlements typology;
4. Scenario development;
5. Development of adaptation options (including climate change adaptation options appraisal criteria);
6. Testing of adaptation options (through scenarios);
7. Review and testing of adaptation options; and
8. Finalisation and synthesis of adaptation options.

The phases are briefly outlined below with the principal ones and their outputs discussed in further detail in Part II.

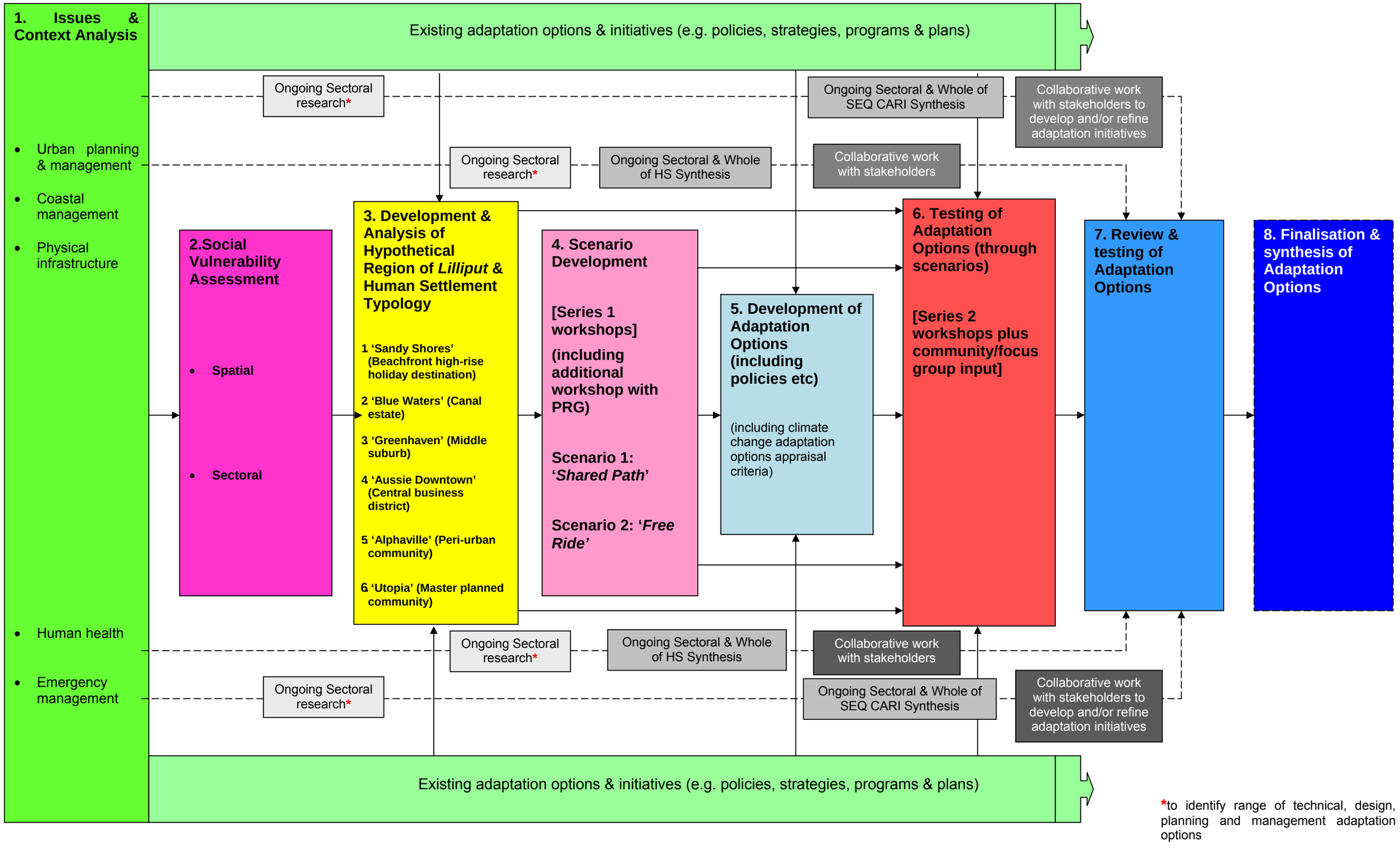


Figure 1: SEQ CARI Human Settlements component's Phased Methodology

The **issues and context analysis** phase was largely conducted through a document analysis and a review of the literature and was aimed at addressing research questions (RQs) 1, 2 and 3 in particular. It resulted in the development of an Issues Paper which included the initial identification of the range of technical, design, planning and management adaptation options currently in operation (see McDonald et al 2010). Ongoing sectoral research through further document analysis enabled the Human Settlements team to evolve and maintain an updated appreciation of existing adaptation initiatives (and their characteristics including barriers) that were introduced from time to time across all sectors throughout the remaining two and a half years of the project.

A **social vulnerability assessment** was conducted to address the Project Brief's scope and intended output 1a (i.e. conduct a spatial assessment of the vulnerability of human settlements in SEQ) (Low Choy et al 2010).

The **development and analysis of the hypothetical region** of *Lilliput* and its human settlements typology was completed to address the Project Brief's scope and intended output 1b (undertake detailed case studies of 4/5 locations that represent key issues for the planning and implementation of adaptation measures in the region) (Low Choy et al 2011). The fictitious *Lilliput* model described the approximate SEQ situation but did not attempt to represent the region's precise details, e.g. demographic characteristics, population growth, biophysical attributes. The rationale and nature of this approach to fictionalising the region and the selected case study areas is discussed in Chapter 7.

Six distinctly different hypothetical case studies were developed to represent a range of human settlement types from SEQ, including:

1. 'Aussie Downtown' – a Regional Activity Centre;
2. 'Sandy Shores' – a beachfront high rise holiday destination;
3. 'Blue Waters' – a canal estate;
4. 'Greenhaven' – a middle suburb;
5. 'Alphaville' – a peri-urban community; and
6. 'Utopia' – a master planned community.

The development of generic and sectoral descriptions for human settlements followed and concluded with an analysis of each human settlement type. A common evaluation framework was employment across the sectors to complete an in-depth investigation in each sector with respect to RQs 1, 2, and 3. By adopting this 'generic' fictitious approach RQ 8 could also be partly facilitated. The opportunity to deconstruct the hypothetical case study and relate the findings back to real-world example sites is also an option for future consideration.

Scenario development was conducted through a series of stakeholder workshops in each of the four participation local government case study areas over a period of a number of months (Low Choy et al 2012). This component of the research was completed to lay the foundations to test various adaptation options and thus address the Project Brief's scope and intended output 2 (develop adaptation options) and RQs 5 and 7.

The **development of adaptation options** was originally conducted in individual sectors to address the Project Brief's scope and intended output 2 (develop adaptation options) and RQs 5 and 7 (Low Choy et al 2012). Cross sectoral adaptation options were subsequently identified. This phase also included the research which led to the development of the appraisal criteria which was used to evaluate the robustness of the climate change adaptation options (see Chapter 8).

The **testing of adaptation options** was achieved initially through a second series of stakeholder workshops which utilised the scenarios previously developed. This phase addressed RQs 4, 5, 6 and 7 along with the reconfirmation of RQs 1, 2 and 3 (Low Choy et al 2012). Chapter 8 provides a summary of these findings.

The **review and testing of adaptation options** was continued through in-depth independent sectoral research involving further stakeholder engagement processes (e.g. stakeholder surveys through interviews) described in Chapter 8. This process reconfirmed RQs 1, 2 and 3 and provided further evidence to address RQs 4, 5, 6 and 7 (Low Choy et al 2012).

The **finalisation and synthesis of adaptation options** was largely accomplished through a series of internal team retreats and workshops supplementing and coordinating the individual sectoral work which was linked by common methodological frameworks (this report and its accompanying Supplementary Report). This process also facilitated the synthesis of the sectoral outputs and the identification and development of cross sectoral adaptation options. It addressed the Project Brief's scope and intended output 2 (develop adaptation options). It also concluded the response to RQs 4, 5, 6 and 7. Chapter 9 provides a full description of this phase and its outputs.

These various phases of the project utilised a variety of tools and techniques. A summary of the different types of tools and techniques that were employed during the eight research phases of the project is provided in Table 1.

In concluding this review of the Human Settlements methodology, it is informative to compare and benchmark its approach and underlying philosophy against 'best practice' for climate change adaptation. A practical and useful yardstick has been reported by Willows & Connell (2003) who have promoted an eight stage decision-making framework, advocating that it "provide(*s*) a flexible approach to decision-making under climate change" (Willows & Connell 2003: vii). They nominate a number of features of this framework that promote good decision-making principles, namely:

1. It is **circular** which emphasises "the importance of the adaptive approach to managing climate change problems and implementing response measures … (*claiming that*) … decisions should be revisited in the light of new information on climate change and its impacts" (Willows & Connell 2003: vii);
2. It encourages **feedback and iteration,** thus allowing "the problem, decision-making criteria, risk assessment and options to be refined as a result of previous analyses, prior to any decision being implemented." (Willows & Connell 2003: 7). They argue that "iteration is important to achieving robust decisions." Willows & Connell (2003: vii); and

Table 1: Tools and Techniques employed in various Research Phases

Tools and Techniques \ Human Settlements Research Phases	Phase 1: Issues & context analysis	Phase 2: Social Vulnerability analysis	Phase 3: Development & analysis of Hypothetical Region	Phases 4: Scenario Development	Phase 5: Development of Adaptation Options	Phase 6: Testing of Adaptation Options through scenarios	Phase 7: Review & testing of Adaptation Options	Phase 8: Finalisation & synthesis of Adaptation Options
Analytic Hierarchy Process (AHP)								●
Brainstorming	●		●	●	●			
Case study analysis			●					
Checklists					●	●	●	●
Consultation exercises	●						●	
Decision conferencing							●[2]	●[2]
Document analysis	●		●		●			
Expert elicitation						●	●	
Expert judgement		●	●	●		●	●	●
Facilitated workshops				●		●	●[2,3]	
Finite Element Analysis								●
Literature review	●	●	●		●			
Modelling tools		●	●					
Multi-criteria analysis (MCA)							●	●
Pairwise comparison							●	●
Policy exercise				●				
Process influence diagrams						●[4]		
Ranking						●	●	●
Scenario planning				●		●		
Scenario modelling						●		
Surveys			●[1]				●	
Targeted interviews					●		●	
What-if analysis						●	●	●

[1] Hypothetical human settlement types recognition survey
[2] Internal HS team retreats and workshops
[3] PRG special workshop
[4] Physical Infrastructure workshop

3. Certain stages (namely 3, 4 and 5) are **tiered** allowing "the decision-maker to undertake screening, evaluation and prioritisation of climate risks and options for the decision which promote adaptation to climate change, before moving on to more detailed risk assessments and options appraisals." (Willows & Connell 2003: 7).

The Human Settlements approach to their research strategy and design is entirely consistent with the underlying framework espoused by Willows & Connell's (2003) approach. In the first instance, the research strategy adopted by the Human Settlements team is characterised by all of Willows & Connell's three key good

decision-making principles of: 'circular'; 'feedback and iteration'; and 'tiered stages'. This is achieved through the strong coincidence of the Human Settlements research phases with the stages in the Willows & Connell's (2003) decision-making framework. This is highlighted in Table 2.

Table 2: Comparison of Human Settlements Research Phases with Stages of Decision-Making Framework for Climate Change Adaptation

<table>
<tr><th colspan="2">Stages of Decision-Making Framework for Climate Change Adaptation
(Source: Willows & Connell 2003)</th><th>Human Settlements Research Phases
(including SEQ CARI Reports)</th></tr>
<tr><td rowspan="2">Structuring the problem</td><td>Stage 1: Identify problem and objectives</td><td rowspan="2">Phase 1: Issues & context analysis (McDonald et al 2010)</td></tr>
<tr><td>Stage 2: Establish decision-making criteria</td></tr>
<tr><td rowspan="4">Analysing the problem (tiered stages)</td><td rowspan="2">Stage 3: Assess risk</td><td>Phase 3: Development & Analysis of Hypothetical Region of Lilliput & Human Settlements Typology (Low Choy et al 2011)</td></tr>
<tr><td>Phase 2: Spatial and Sectoral Vulnerability Analysis (Low Choy et al 2010)</td></tr>
<tr><td>Stage 4: Identify options</td><td>Phase 5: Development of Adaptation Options (Low Choy et al 2012)</td></tr>
<tr><td>Stage 5: Appraise options</td><td rowspan="2">Phases 4: Scenario Development and Phase 6: Testing of Adaptation Options through scenarios (Low Choy et al 2012)</td></tr>
<tr><td>Decision-making</td><td>Stage 6: Make decision</td></tr>
<tr><td rowspan="2">Post-decision actions</td><td>Stage 7: Implement decision</td><td rowspan="2">Phase 7: Review & testing of Adaptation Options and Phase 8: Finalisation & synthesis of Adaptation Options (This report)</td></tr>
<tr><td>Stage 8: Monitor, evaluate and review</td></tr>
</table>

Willows & Connell (2003) have also noted the appropriateness of the various tools and techniques that were employed in this study (see Table 1) to the respective stages of their decision-making framework for climate change adaptation – thus Table 2 can also be used to establish this cross framework association of tools and techniques.

The second level of conformity between Willows & Connell's (2003) framework and the Human Settlements team's research design lies in the planning paradigm that was adopted to examine and advance the adaptation options. It too was of a 'circular' nature in the form of the cyclic planning process (see Figure 2).

The proposed adaptation options have been framed in an adaptive management context and have been derived through the consideration of a cyclic planning process that incorporates an adaptive management framework. This facilitates the ability to continuously review these options in the light of new and revised science and learnings. This cyclic approach has meant that implementation issues have had to be considered and aspects of monitoring and evaluation addressed in terms of the implementation of the adaptation options.

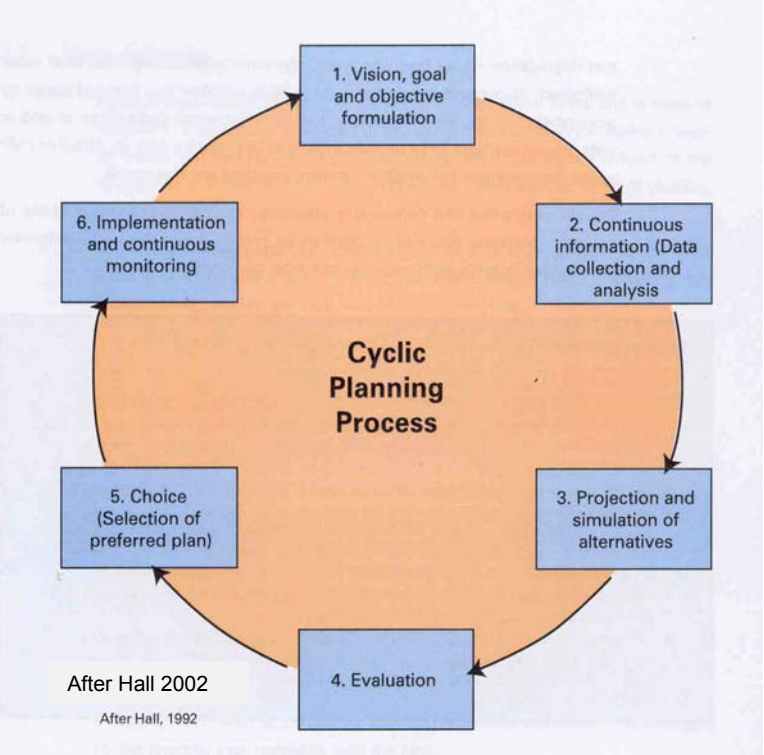


Figure 2: Cyclic Planning Process

The Willows & Connell's (2003) framework stresses the importance of an open approach to decision-making, which takes account of the legitimate interests of stakeholder and affected parties. Where appropriate, the decision process should encourage active participation from interested groups. Among other benefits, this will help minimise the risk of overlooking potential impacts, and of failing to identify adaptation constraining decisions. It should also ensure that differences in the perception of risks and values are fully explored within the risk assessment and decision appraisal process (Willows & Connell 2003). The Human Settlements approach incorporated a significant commitment to stakeholder engagement which is fully described in Chapter 4.

As previously noted, RQ 8 (transfer of lessons learnt) can only be partly addressed in this study through, for example, the fictionalised human settlements typology. The adoption of an adaptive management frame for the developed adaptation options and the cyclic planning context in which they are positioned will also assist to achieve the intent of RQ 8. However, any further achievements towards this RQ must be made through, and as a consequence of, the actual implementation of the proposed adaptation options, which is possible within the frameworks that have now been set up through the outputs of the Human Settlements research.

4.0 STAKEHOLDER ENGAGEMENT

The Human Settlements team's engagement with stakeholders throughout the three year duration of the project was directed by its *Communication, Stakeholder Engagement and Adoption Strategy* (dated September 2010). Two key undertakings of the project's research strategy were to:

1. Work with government, industry and community groups to explore potential adaptation options, which will include new approaches to urban planning, coastal management, physical infrastructure planning and delivery; emergency services responses, human health; and
2. Work with key stakeholders in the region to explore adaptation options in terms of capacity building, planning, management and policy and devise pathways to implementation.

To these ends, stakeholder engagement was achieved on a number of levels and in a number of ways, namely through:

- Continual engagement throughout the duration of the project (three years) in the form of membership of a Project Reference Group (PRG);
- Participants at the two series of workshops conducted over an eighteen month period;
- Individual interviews; and
- Targeted consultation with specific stakeholder interest groups.

A **Project Reference Group (PRG)** was established to guide the project. This expert reference group was drawn from key stakeholders in each jurisdiction, including state and local government[3], industry and the community, and included:

- The four case study local governments informing the project (Gold Coast City Council, Moreton Bay Regional Council, Ipswich City Council and Sunshine Coast Regional Council);
- Department of Local Government and Planning;
- Department of Environment and Resource Management – Office of Climate Change;
- Queensland Health;
- Department of Community Safety - Emergency Management Queensland;
- Local Government Association of Queensland;
- SEQ Catchments;
- Queensland Council of Social Service;
- Queensland Coastal Council Group; and
- Urban Development Institute of Australia (Queensland Branch).

The role of the PRG and its members was to:

- Participate in Reference Group meetings;
- Provide a forum for the researchers to discuss ideas, progress and seek stakeholder opinion, advice and support;
- Provide reviews of project outputs and comments on draft reports;

[3] Names and titles of state government agencies that were active at the time of the research have been maintained for the purposes of this report.

- Guide the project team to relevant data sources and information;
- Identify key contacts and information for the project, suggest target audiences for project outputs and, where appropriate, promote the project and its findings in appropriate forums;
- Provide input regarding communication guidelines and strategies;
- Assist the project team to disseminate the project outputs through their respective networks; and
- Provide advice on linkages to other relevant programs and projects in the project study areas.

Engagement through the workshop series obtained good representation across all sectors, at the desired levels of government and including the non-government sector (see Low Choy et al 2012). Workshops were designed to be 'by invitation only' and targeted representation from all major stakeholder groups that were representative of the five sectors comprising the Human Settlements component of SEQ CARI.

Interviews with selected key stakeholders were employed by the Human Settlements team to supplement the findings from other collaborative undertakings, particularly the workshop series. The primary objective of these interviews was to increase sectoral understanding of the policy process within government and non-government organisations, including policy development and implementation with implications for climate change adaptation. Thirty semi-structured interviews were conducted with interviewees purposively selected to include practitioners from all five sectors (included executive, senior and middle managers, working primarily in policy, planning, capacity building and engineering fields) – see Table 3.

Table 3: Attributes of Stakeholder Interviews

Stakeholder group	Number of Interviews	Predominant field of work
Local Government	15	Planning, engineering, health, emergency management
State Government	7	Planning, engineering, health, emergency management
Peak Bodies	3	Planning, policy, capacity building
Non-Government Organisation	3	Planning, environment, capacity building
Private Sector	2	Engineers, capacity building, health

(After: Low Choy et al 2012)

In terms of stakeholder participation, the overall number of participants that engaged with the Human Settlements team during the three-year course of the research project through all forms of stakeholder engagement activities that were completed is tabulated below (see table 4).

A key factor that was crucial to the success of the project, and particularly to the workshops, was the level of representation of key stakeholder groups that was achieved. In particular, this went to the seniority of the participants involved, and their representation and coverage of all key Human Settlements sectors at local and state government and non-government levels.

Table 4: Stakeholders involved in the Human Settlements component of SEQ CARI over the three-year study period

Stakeholder engagement process		Number of participants
Series 1 workshops	*Workshop 1 (Sunshine Coast)*	14
	Workshop 2 (Gold Coast)	15
	Workshop 3 (Moreton Bay)	15
	Workshop 4 (Ipswich)	13
Series 2 workshops	*Workshop 1 (inland)*	21
	Workshop 2 (coastal)	21
Infrastructure workshop		6
Project Reference Group (4 meetings, including tailored workshops)		12
Additional stakeholder consultation		7
Stakeholder interviews		30
Total number of participants/participations		**190**

PART II

5.0 KEY ISSUES

5.1 General

The Issues Report (McDonald et al 2010) laid the foundations for the Human Settlements component by identifying the key issues, confirming research questions, and developing the policy context(s) for the project. It was noted that the institutional and policy landscape within which adaptation decisions for the region must be made is complex and fragmented. There are multiple agencies, from the national to the local level and across sectors, whose activities and decisions affected the way in which adaptation can occur at the local level.

These agencies and organisations are discussed in the Issues Report (McDonald et al 2010). The plethora of legislative instruments, policies, plans and strategies, some of which address climate change issues directly, others whose impact on regional adaptation efforts is more oblique, were also recognised and discussed.

Having reviewed the institutional and policy context, the climate projections and the demographic and development trends for the region, the over-arching goals and research question for the project were explored and confirmed.

The initial scoping of current climate change projections and impacts for SEQ identified a number of trends and issues that required attention in the decision making processes governing the region (see Table 5).

The Issues Report also identified the key issues and trends for each of the five sectors covered by the Human Settlements component. These are outlined next.

5.2 Issues and trends for urban planning and management

The population of SEQ continues to grow, placing considerable development pressure on new parts of the region. In addition to these new pressures, SEQ, like many parts of Australia, also inherits a legacy of earlier planning decisions and land use commitments based on expected historical return periods of weather events such as floods.

The location of existing infrastructure and settlements in areas highly exposed to the projected impacts of climate change places those buildings and assets, and the people who live or work in them, at increased risk of harm. For instance, in SEQ, 75% of the 200,000 properties built pre-1960 are located within 10 km of the coast and could be subject to coastal hazards, such as sea level rise and storm surges (Wang et al 2010). The same trend of coastal location applies to commercial and services buildings as well as a significant portion of transport networks (Wang et al 2010).

Table 5: Climate change impacts and associated sectoral issues for SEQ

Sector	Climate Change Impacts and Associated Issues			
	Higher temperatures	**Variable rainfall**	**Extreme weather**	**Sea level**
Urban Planning and Management (incl. Coastal Management	Property damage through bushfire Intensification of heat island effect	Flood risk to consolidated urban areas Inadequate water supply for urban areas	Increased damage to private property from storms, landslides, floods, bushfires, storm surges	Increased damage to private property and reduced property values from severe storms combined with rising sea levels leading to severe erosion/ inundation
Physical Infrastructure	Pressure on the energy grid during heatwave events and associated risks of supply failure and business disruption Accelerated deterioration of heat-sensitive infrastructure, such as road surfaces.	Pressure on water supply systems Damage of existing Infrastructure due to flooding Failure of sewage and wastewater systems during intense rainfall	Increased damage to public infrastructure from storms, landslides, floods, bushfires, storm surges Disruption to essential services such as electricity, water, sanitation Business disruption in disaster-affected areas	Damage to public coastal Infrastructure from severe storms combined with rising sea levels Rising water tables with flow on effects for underground infrastructure due to sea levels Increased exposure of concrete foundations to salt water to affect structural integrity and longevity
Emergency Management	Impacts on electricity and flow on effects for essential services, e.g. communication networks, ability to use high rise elevators, sewerage and other services	Flooding of underground carparks reducing private vehicle access Evacuation routes impeded	Stranding/impacts on evacuation routes especially for elderly residents and those requiring assistance Hazards from debris	Hazards from erosion of river bank and damage to infrastructure
Human Health	Mortality and morbidity during heat wave events (especially significant with an ageing population) Spread of vector-borne and food-borne diseases Death and injury resulting from bushfire Increased stress on public health systems during heatwave events	Spread of vector-borne diseases	Risks to human life and health from flooding and storms	Risks to human life and health from flooding and storm surges

(Source: McDonald et al 2010)

At present, the principal focus of planners is on minimising exposure of new developments to future risks, but urban renewal and consolidation initiatives aimed at accommodating increasing population pressures in existing settlement areas will also have to consider increased exposure to climate-related hazards. In both contexts, planning decisions will have to consider the relationship between climate change projections and existing and future urban growth areas. Planning decisions will also need to take into account climate change scenarios to guide future strategy and policy development.

Urban planning and management therefore faces a two-tier challenge: how to incorporate climate change considerations in planning for new development in the region; and how best to manage the redevelopment and retrofit of existing settlements.

Challenges for urban planning and management in SEQ include:

- How to account for climate change impacts in local and regional statutory and non-statutory plans, and how to balance those with other non-climatic drivers of regional scale landscape change?
- How best to strike the balance between mandatory and voluntary adaptation and engage the non-government sector in the climate adaptation decision making process?
- The need for horizontal and vertical coordination and integration between planning and other adaptation instruments within the region, and between land use and infrastructure planning (including provision and maintenance of infrastructure).
- Ensuring that adaptation strategies and planning for the urban landscape do not undermine adaptation options for adjacent natural areas or compromise the long term biodiversity conservation value of those areas.
- Identifying and overcoming legal and other barriers to climate change adaptation through statutory and non-statutory planning.
- How best to prioritise policy response to specific climate change impacts at local and regional level?

5.3 Issues and trends for coastal management

Climate change in SEQ's coastal zone, in terms of sea level rise, changing wave climate patterns and heavier storm surges, is likely to lead to major impacts on the region's community, economy and environment. Approximately 85% of Australians live within the coastal zone and about 711,000 residences are within 3 km of the coast and less than 6 m above sea level (Department of Climate Change 2009). These figures are even more pronounced for the SEQ region, with five coastal councils (Gold Coast, Brisbane, Redland, Moreton Bay and Sunshine Coast) hosting more than 50% of the total Queensland population (Roiko et al 2010).

The number of coastal residents and tourists has grown to unprecedented levels in the last two decades and is projected to keep on growing in the future, with coastal lifestyle and the 'sea change' phenomenon being the major drivers for population growth. Coastal infrastructures, including defence structures, ports, harbours, waterways and artificial beaches, are critical assets supporting a wide array of

industries (e.g. transport, fisheries, and tourism) could be heavily affected by gradual changes in sea level and extreme events.

Planning and management strategies at state and regional level are now starting to incorporate the best projections of sea level rise, but do not account for wave climate and storm variability, for which projections for SEQ are not yet available. Planning for adaptation should commence even in a context of uncertainty about future scenarios, as failure to address risks today may make it more costly to adapt in the future (Mummery 2008).

To minimise problems of fragmentation and poor coordination across local authorities, state or Commonwealth coordinated government guidelines are needed. In this context, challenges for coastal management in SEQ include:

- How to incorporate climate change projections, including sea level rise and storm variability, in the current planning instruments in a way that enables those instruments to be updated when new science emerges?
- How to identify the best technical options for coastal adaptation and assess the cost and benefits of different adaptation strategies, justified for different socioeconomic contexts?
- How to communicate coastal climate change issues to local communities in order to facilitate the adoption of new provisions and strategies for climate adaptation?

5.4 Issues and trends for emergency management

Over recent years, there has been a paradigm shift in disaster management approaches away from a focus on response to a stronger emphasis on an all-hazards approach to prevention or mitigation of the consequences (Pitman 2006; COAG 2002). This transformation to a community safety paradigm is characterised by:

- shared community responsibility;
- identifying and protecting those at risk;
- securing sustainable reductions in the source of hazard;
- reduction in unreasonable fear of the hazard;
- development of community based programs;
- development of multi-agency partnerships; and
- community level engagement and empowerment (Elsworth et al 2009).

An improvement in all phases of disaster management - prevention, preparedness, response and recovery - will be needed to deal with the expanding and changing risks caused by climate change. Improved prevention involves strengthening coordination across government and improving land use planning and management by making disaster risk reduction a specific consideration in building codes and planning regimes. Strategies to improve preparedness for natural disasters require alignment of state, regional and local disaster management plans, community awareness and understanding of events, better resourcing and use of community networks to enhance disaster management resilience and anticipation of post disaster needs.

There currently appears to be very limited community engagement with disaster awareness and preparedness except among people who have recently experienced an event (Dyer et al 2001; Department of Infrastructure, Transport, Regional Development and Local Government 2008).

Response to an event requires a combination of operational capability and coordination across the various elements of the disaster management system, consistent application of response planning tools, a strong volunteer force and, where possible, pre-deployment of personnel and assets in anticipation of an emergency or disaster. The emergency management sector is increasingly reliant on an extensive network of volunteers, but there are limits to this resource. The volunteer sector will need to be strengthened to manage the expected increase in disasters resulting from climate impacts. Barriers to volunteer service need to be addressed by each level of government to overcome the current decline in the numbers of volunteers in the emergency management sector.

Evacuation during extreme events will be an important mechanism by which to minimise potential impacts on human health and wellbeing. Early evacuation is the most effective solution for the aged or infirm, but comes with risks of adverse health effects from prolonged evacuation (Kirkpatrick & Bryan 2007). Impaired mobility will affect the ability of individuals to evacuate and emergency planners in the SEQ region need to understand the true numbers of people with special needs and identify patients reluctant to evacuate well in advance.

Recovery refers to the regeneration of a community following a disaster. It includes minimising any exacerbation of the consequences of a disaster, regenerating the social, emotional, economic and physical wellbeing of the individuals and communities, and taking opportunities to reduce future exposure to hazards and their associated risks (Norman 2006). Community recovery requires a holistic approach that encompasses social, economic, infrastructure, and environmental considerations, preparation of a comprehensive plan for short and long term recovery needs, a proactive communication strategy, disaster relief arrangements, and sound business continuity practices (State Disaster Management Group 2005).

Challenges for the emergency management sector in SEQ in the face of climate risks include:

- Ensuring that increased climate risks are integrated into state and local disaster management plans;
- Improving and/or rethinking the governance, coordination of, and communication between the agencies involved in emergency management within the SEQ region;
- Managing or changing the community expectation that all emergency events can and will be anticipated and managed;
- The implications for SEQ of Queensland's reliance on a high level of volunteer support, in circumstances where any increase in the frequency of severe weather events will place greater demands on volunteer time (McLennan et al 2009);

- How emergency managers should deal with complexity and uncertainty over trends in how future climate change will affect the location, likelihood/frequency and severity of disasters are poorly understood; and
- Trade-offs between options, ranging from warning systems and emergency responses to improved land use planning and enhanced building design and construction in preventing or reducing risk, to risk transfer mechanisms such as insurance.

5.5 Issues and trends for human health

The impact of climate on human health is both direct (e.g. thermal stress, flood and fire injury and death) and indirect, through disease (e.g. Ross River fever), contamination (e.g. food and water supply) and environmental degradation, such as poor air quality and loss of crop land (McMichael et al 2003; Confalonieri et al 2007; Patz et al 2005). Direct health impacts tend to be dramatic but, in relative terms, restricted in time and scope. Indirect impacts are more insidious with the potential for enduring and widespread social consequences. The drama of the immediate physical damage wrought by natural disaster, portrayed in images of incinerated structures, floating towns and highways of wind destruction, tends to obscure personal and social costs. Nevertheless, the longer-term damage to households and communities should not be underestimated.

The actual health consequences of climate change are strongly influenced by the socioeconomic context. The more cohesive and/or wealthy the community and the more developed the institutional and technological structure, the greater the capacity to respond to both the catastrophic and structural health challenges of climate change. The age structure of the impacted population is also important with the aged, infants and people with underlying poor health being particularly vulnerable. The health impacts of climate change also vary widely by environmental setting. Affected areas may, for example, be tropical or temperate, rural or urban, coastal or inland and so forth.

In summary, the health impacts of climate change are complicated by social and environmental factors and cannot be directly correlated with the simple metrics of climate change such as variation in temperature and rainfall or, even, projections of extreme events. Climate change is expected to result in changes to existing health issues, rather than lead to the emergence of new issues. There is, therefore, a need to concentrate on known health burdens that are likely to be exacerbated by climate change impacts, and the most effective, efficient and equitable approaches to those exacerbated risks.

Challenges for the health sector in SEQ include:

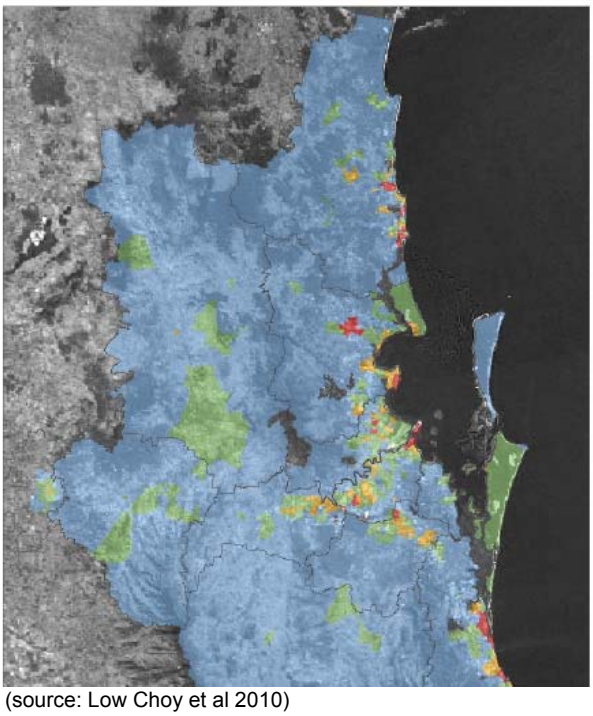
- Obtaining a clearer understanding of the extent of the future health burden and a greater focus on disease prevention in the region;
- Rethinking health planning timeframes from short term to more medium and long-term;
- Ensuring that effective surveillance and response systems are in place to manage any increases in infectious diseases;

- Rethinking communications policies and procedures, to include behavioural, knowledge and attitudinal shifts (Frumkin & McMichael 2008);
- Developing integrated and inter-agency measures that help reduce the potential impact of events on vulnerable populations, especially as many climatic risks to health lie beyond the usual scope of the public health sector; and
- Developing measures to articulate the work of local public health responses into broader inter-state or national responses. This is especially important as the impact of extreme events may cross state boundaries or involve a broader national response.

6.0 VULNERABILITY ASSESSMENT

This phase consisted of a preliminary regional assessment of the vulnerability of human settlements to climate change at both spatial and sectoral levels. In SEQ, climate change is projected to lead to an increase in average annual temperatures, a change in average rainfall and sea-level rise. In addition, more extreme weather events are projected, with an increase in extreme rainfall events, an increase in the number and frequency of more intense cyclones and an intensification of east coast lows (see Low Choy et al 2010).

The spatial vulnerability assessment utilised an integrated framework which included of vulnerability, as this was the most common approach used in global environmental change and climate change research at that time. Preliminary regional spatial vulnerability assessments were developed, based on a set of indicators to illustrate the region's exposure, sensitivity and adaptive capacity to three key climate-related impacts projected to affect the region, namely: extreme heat, extreme rainfall and coastal hazards. Figure 3 illustrates the 2010 combined SEQ vulnerability assessment to extreme heat, extreme rainfall and coastal hazards. Whilst it represents a preliminary assessment based on data available at that time, it does provide a snapshot of possible conditions under potential extreme weather events and an indication of issues that need a policy and planning response.



(source: Low Choy et al 2010)

Figure 3: Combined SEQ vulnerability to extreme heat, extreme rainfall and coastal hazards

The initial spatial vulnerability assessment for extreme heat indicated that areas associated with the region's urban footprint (including coastal urban areas) are generally more exposed to heat impacts due largely to heat trapped in the urban canopy as a result of expanded impervious surfaces. This was the case in urbanised coastal areas of the Gold Coast

and the Sunshine Coast, plus the bayside areas of Brisbane City and Moreton Bay Regional Council areas, which included a number of localities assessed to be extremely vulnerable to the impacts of extreme heat events. Some of these localities that were identified as highly vulnerable to extreme heat were also areas with low adaptive capacity. This was particularly noticeable in the south west of Brisbane City and in north east portions of Ipswich City.

The assessment of extreme rainfall vulnerability indicated that overall most of SEQ had a low vulnerability to extreme rainfall. However, some specific areas within local government areas of Gold Coast, Brisbane, Logan, Moreton Bay and Sunshine Coast presented a medium, high and extremely high vulnerability to extreme rainfall. Of particular concern were a number of areas within the Sunshine Coast and Gold Coast jurisdictions that appeared extremely vulnerable to extreme rainfall. Extreme rainfall leading to flooding events affecting these areas could also be potentially intensified if there was a coincidence with coastal hazards, such as storm surges and king tides.

The most vulnerable areas to coastal hazards have been assessed as locations associated with the local government areas of the Sunshine Coast, Gold Coast, Moreton Bay, and Brisbane. Whilst Redland City demonstrated a medium level of exposure and extremely high level of sensitivity to coastal hazards, its high level of adaptive capacity resulted in the area's overall low vulnerability to coastal hazards.

The sectoral vulnerability assessment focused on the key Human Settlements sectors of urban planning and management, coastal management, human health and emergency management.

For the urban planning and management sector, the assessment identified that local authorities in the region had made considerable progress in developing policies geared toward climate change strategies in the last few years despite the fact that there was no statutory obligation to do so. On the other hand, the analysis of the current planning schemes illustrated that adjustments need to be made in order to improve planning practices. This included more flexibility in the planning process through adaptive management in order to deal with uncertainties and evolving climate science, better cross-scalar and cross sectoral integration in the policy delivery process, improved governance through better coordination between tiers of government, private sector and public engagement, as well as the establishment of provisions that could specifically deal with climate change related hazards. A number of barriers needed to be overcome, especially by local authorities, to implement climate change adaptation strategies in a well-coordinated and holistic manner that integrates multiple sectors.

Key findings for the coastal management sector highlighted the vulnerability of SEQ's coastal areas and the weaknesses of the current coastal planning and management system. A reduction of vulnerability in coastal areas needs to consider the identification of sustainable options to defend, accommodate or retreat communities to safer areas to address the future challenges posed by climate change. Specific initiatives to reduce vulnerability to climate change-related coastal hazards in SEQ should seek to increase the adaptive capacity of coastal systems. In addition, the management of coastal adaptation in a context of uncertainty and

changing climate projections required more flexible mechanisms to incorporate new sea level rise and wave climate figures into coastal plans and shoreline erosion management plans. New concepts need to be integrated into local planning schemes, such as dynamical buffer zones capable of accommodating worst case scenarios with overall lower costs for the society in the long term.

It was noted that climate change had received little and only recent attention by the emergency management sector. The majority of emergency management policies and plans at national, state and local levels did not integrate climate change adaptation considerations or even mention climate change as a future threat. Climate change, however, does bring new challenges to the emergency management sector in SEQ. An improvement in disaster risk assessments and in the prevention, preparedness, response and recovery phases of disaster management is necessary in order to deal with the expanding and changing risks caused by climate change.

With regards to the health sector, successfully addressing the challenges posed by climate change requires an understanding of the complexity of stressors and external drivers impacting on human health as a result of climate events. It was considered important to differentiate and understand how the complexity of adaptive climate change strategies will play out at neighbourhood or community scale as opposed to broad regional measures, as there can be no guarantees that the higher order initiatives will successfully translate to the smaller local scale. Local and state level health programs could be better targeted through an improved understanding of how local vulnerabilities are produced and their potential spatial extent across the region. In essence, it was considered that a better understanding of the vulnerabilities would aid health planners and policy makers to effectively develop appropriate measures across all four phases of prevention, preparedness, response and recovery.

In view of the complexity of the vulnerability assessments undertaken, and their outputs, it was concluded that a cooperative monitoring program needed to be established across the region to collect and update relevant regional and local climate science in order to better inform future vulnerability assessments, which in turn will greatly assist planning and decision-making processes. In addition, it was considered worthwhile to explore the implications involved in adopting the Precautionary Principle when developing adaptation options for SEQ. Notwithstanding the challenges of this undertaking, it was considered that this process could result in more effective climate adaptation strategies across the region and across sectors.

7.0 HYPOTHETICAL CASE STUDY

In addressing the SEQ region and its eleven local government areas, it was necessary to identify and negotiate the participation of an appropriate number of local government case studies. These local government areas were also selected on the basis that they included a representative sample of human settlement types from the SEQ region. To this end, four local governments were suitably identified and agreed to participate in the collaborative research, namely: Gold Coast City

Council, Sunshine Coast Regional Council, Moreton Bay Regional Council and Ipswich City Council (Low Choy et al 2011).

Initially, negotiating access to case study settings presented some challenges. The main challenge centred on the potential sensitivities to applied research at the community level that involved uncertain climate science and had a strategic nature that dealt with long time frames of twenty plus years, well beyond the political cycles and the time frames that local governments had thus far developed solid policy for. Additionally, this uncertain science-policy research would be occurring within the context of a much broader, national-level, politically changed climate change debate.

These barriers, which were of a political, institutional, social and legal nature, arose in a context where there has been very limited focus on climate change adaptation (especially in comparison to mitigation) and had occurred in the absence of strong leadership on climate change adaptation from all levels of government. There was also the possible perception that the research outputs might conflict with past decisions and/or existing policy where agencies had limited capacity to deal with at present.

These potential 'project stopping' barriers were overcome through negotiated agreements with participating local authorities to undertake the research using a hypothetical case study approach. Hypotheticals are situations (or questions) related to something imaginary rather than something real. They can provide a means for understanding what we would do if the world was different (e.g. in considering climate change related scenarios). This approach can assist the understanding of risk and help to plan and adapt to a desired future. Hypotheticals can also assist in interpreting and understanding the past. The context of the adopted approach is summarised by the philosopher David Lewis (1973) when he suggested that the use of hypotheticals ('counter-to-fact-uals') means that: "In an imaginary world, exactly like ours, except in the one difference we are talking about ...".

Whilst such hypothetical or disguised cases have acknowledged value for this form of research, their anonymity can potentially constrain independent research and analysis of the individual specific case. However, on the positive side, hypothetical case studies can:

- allow the exploration of and development of worst-case scenarios;
- research cases from original sources;
- assess the impact on a wider range of stakeholders;
- consider the case in different cultural, political and geographic contexts; and
- allow exploration and development of alternative courses of action (e.g. adaptation options).

Whilst the disguised approach involving hypothetical case studies was initially employed to overcome issues of a political sensitivity nature, there was also a 'flip side' that should be acknowledged – i.e. the potential opportunity to develop 'grounded' adaptation options and the demonstration of their applicability to a wider area/region. Hence, the hypothetical case studies were used to:

- provide a platform to facilitate discussion and debate among stakeholders;
- overcome the barriers and address the sensitivities previously noted;
- protect the anonymity and identity of stakeholders and participants;

- combine data from a number of data sources; and
- as a basis to construct narratives of possible futures and potential outcomes resulting from 'hypothetical' decisions and actions which may be of appeal to, and useful for reflection and deliberation by, a wider range of interest in climate change adaptation and policy.

As previously noted, this hypothetical approach could pay a part in facilitating RQ 8.

The SEQ region is represented by the *Lilliput* model. Its description approximates the SEQ situation but does not attempt to represent the region's precise details (e.g. demographic characteristics, population growth, biophysical attributes). Within the *Lilliput* region, six discrete hypothetical human settlement types have been developed based on 'real' data sources from local authorities and other agencies relevant to the selected case studies. The descriptions (including supporting maps, data tables and graphics) of the hypothetical human settlements have been fictionalised with disguised designated locations, place names, defining characteristics and attributes and dates.

Consequently, six different case studies were selected to represent a range of human settlement types typical of the SEQ region. They included a:

1. Regional Activity Centre (*Aussie Downtown*) – a seat of government (including local, state and federal government agencies and services); regional economic centre; major service centre for the district (see Department of Infrastructure and Planning 2009);
2. Beachfront high rise holiday destination (*Sandy Shores*) – direct coastal location with high amenity and property values and high population density (including seasonal variations);
3. Canal estate (*Blue Waters*) – extensive residential precincts largely with water focussed lifestyles; new and old (1970s) housing developments;
4. Middle suburb (*Greenhaven*) – largely residential with low quality and ageing housing stock; largely rental accommodation including public housing; low lying and flood prone;
5. Peri-urban community (*Alphaville*) – rural-urban interface; extensive rural residential developments and hobby farms; dominated increasingly by 'tree changers'; and
6. Master planned community (*Utopia*) – a future urban settlement; in a nominated growth corridor; a 'smart city' development.

This has resulted in the development of a generic and sectoral descriptions and initial analysis of each human settlement type (Low Choy et al 2011).

8.0 SCENARIO PLANNING

The next research phase involved a scenario planning exercise with associated activities that involved the development, through extensive stakeholder engagement and feedback, of two scenarios. They were used as 'test beds' in which to explore the relevance and strength of selected preliminary adaptation options for the hypothetical *Lilliput* region representing SEQ. These activities were focussed towards addressing the question of which adaptation options should be employed in *Lilliput* and its different human settlement types to reduce the effects of climate change (Low Choy et al 2012).

This future *Lilliputan* world included a *Shared Path* scenario which was characterised by extremely high levels of community acceptance of responsibility and involvement in governance and in the management of community affairs operating in a political system offering a high degree of inclusive governance for its citizens. By contrast, a second scenario was also developed, the *Free Ride* scenario, which was characterised by extremely low levels of community responsibility and involvement in governance and in the management of community affairs that operate in a political system offering a high degree of exclusive governance for its citizens.

Parallel to the scenario planning process was the development of an initial set of adaptation options for the five sectors comprising the Human Settlements component - urban planning and management, coastal management, emergency management, human health and physical infrastructure related to local government. Subsequent to the testing of these adaptation options through the stakeholder derived scenarios, a range of key stand out responses and messages emerged from a raft of stakeholder engagement processes including the scenario planning workshops, surveys, interviews and the Project Reference Group. Essentially the responses and feedback fell into six groupings, namely: i) Preparing the Community; ii) Support for Vulnerable Communities; iii) Community Leadership; iv) Proactive (Anticipatory) Initiatives; v) Disaster and Recovery Management; and vi) Managing the (Urban) Environment.

The most consistent response from all stakeholder engagement processes referred to the need to provide continuity to climate change adaptation initiatives and to underpin them with support including awareness, education and capacity building programs, particularly due to the long time frames that such initiatives would be required to be implemented to achieve success. This continuity of support should be underpinned by ongoing communications and capacity building of a high quality that engaged the whole community with particular inclusion of vulnerable groups.

Likewise, all stakeholder groups, industry, government and the community, consistently advocated for higher levels of collaboration and partnerships in relation to the full range of climate change adaptation initiatives, inclusive of, but well beyond the development of adaptation options. This it was argued, would lead to improved synergies within the community, foster a fuller sense of community, and lead to a greater acceptance of their shared responsibilities, not too dissimilar to many of the attributes of the *Shared Path* scenario. In this regard, it was also suggested that climate change adaptation could had an added advantage of contributing to the

building of social capital in the communities where adaptation was implemented. This is an issue that certainly requires further research.

There was strong feedback against compulsion and regulation from certain stakeholders such as the development industry. To a lesser extent, some areas of local government signalled support for this view in some circumstances, whilst at other times, the local government message from other quarters was mixed and the feedback was the reverse. It was argued that some adaptation options should be implemented only after extensive consultation and then at the discretion of affected but informed parties, and particularly at times such as the retirement of assets. The adaptation option that typified this form of feedback was the 'Planned Retreat' option.

It was equally clear that the successful implementation of a number of the adaptation options would require the serious address of the 'injurious affection' question by the state government, with the total support from local government. It was previously concluded that this matter is a major stumbling block to the successful implementation on a number of the adaptation options.

A number of stakeholders, particularly from state government and the development industry, made representation that further research was required to provide greater specificity to the proposed prescriptive and implementation measures of a number of the adaptation options, particularly those associated with the 'Building Code' and 'Infrastructure Design Standards'.

A further clear and consistent message that emerged through the feedback from all stakeholder groups concerned the need to secure stronger leadership at all levels in government, the private sector and the community to improve the acceptability of adaptation options. In some instances, this requirement would involve positive government leadership which at times might extend to intervention in order to ensure a higher chance of success with the implementation of the adaptation options. At other times, other adaptation options could be successfully implemented through the self empowering attributes of a *Shared Path* community, especially if they were combined with strong leadership, adequately resourced and maintained continuity of effort and message. This desire for strong leadership was couched in a highly consultative and partnership framework as noted previously. Not to do so it was argued would lead to the stalling or failure of the adaptation option.

The leadership issue also arose in relation to the physical infrastructure investigation which sought to ascertain the upper thresholds of local government commitment to reinvest in physical infrastructure post natural hazard occurrences such as floods. The preliminary conclusions noted that the thresholds could be influenced by funding sources (particularly the Commonwealth Government), the financial and technical capacity of local government; levels of political, professional, business and community support and the cycle of repetitive occurrence of natural hazards.

Joint arrangements for the implementation of many of the options were also recommended through a mutually supportive, coordinated and cooperative effort, especially between government agencies. These joint arrangements, along with the positive feedback from the high level stakeholder assessments of the various engagement processes associated with the project, will provide a clear way forward with direction and support for the finalisation of Human Settlements adaptation options.

PART III

9.0 DEVELOPMENT, ASSESSMENT & SYNTHESIS OF ADAPTATION OPTIONS

The development, compilation, assessment and synthesis of adaptation options for the Human Settlements component followed a unique sequence of steps derived by the Human Settlements team which spanned across a number of the project phases.

In the first instance, the development of adaptation options was informed through individual and team iteration and by a document analysis of existing adaptation related initiatives in association with a literature review. These three sources gave rise to the formulation of three types of adaptation options, namely:

1. Existing adaptation options (e.g. from current strategies etc);
2. Modified adaptation options (i.e. adapted from existing adaptation options); and
3. New adaptation options derived by the Human Settlements team.

Various tools and techniques (see Table 1) were employed in the formulation of the adaptation options as illustrated in Figure 4.

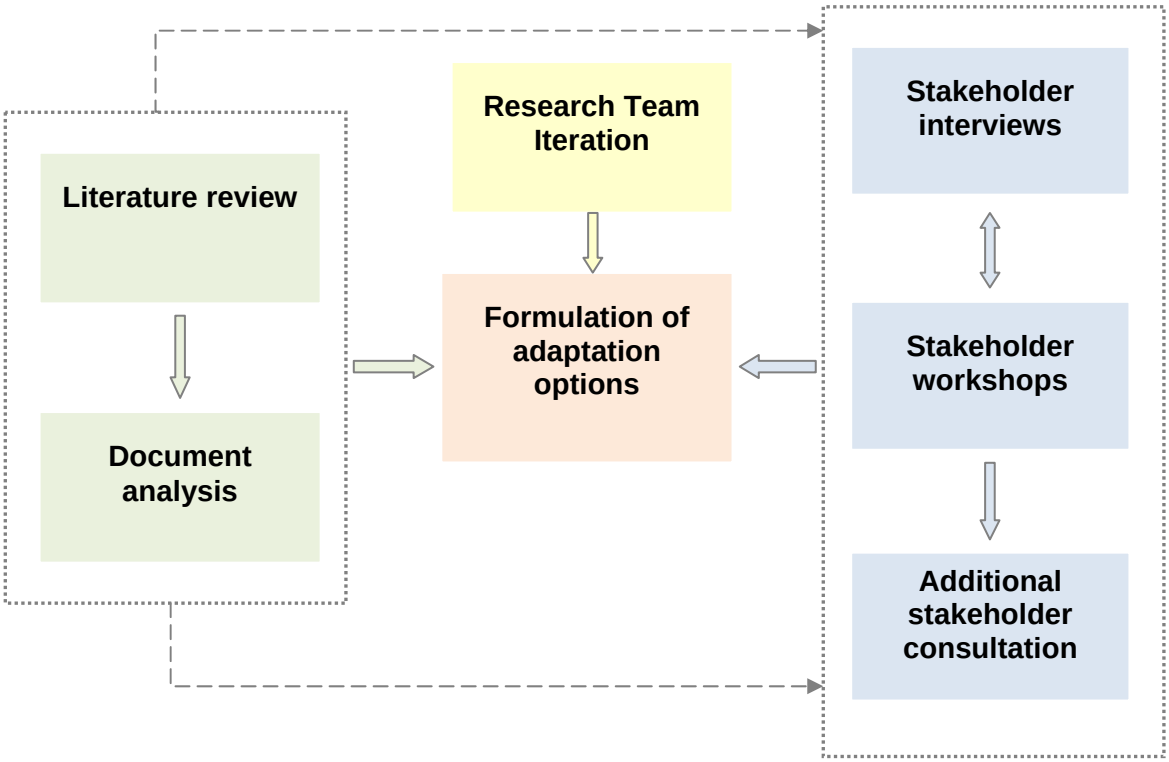


Figure 4: Formulation of Adaptation Options Process

The document analysis focused on existing planning and policy initiatives at the national state, regional and local scales and from within the selected case studies. Documents reviewed included: national policies, frameworks and guidelines; state-

wide policies and plans; regional plans and policies; local planning schemes; local strategies, plans and programs directly or indirectly related to climate change adaptation (see Appendix B for a full list of documents examined). This analysis was complemented by a literature review on climate change adaptation across the sectors elsewhere in Australia and overseas. The purpose of this document analysis was:

1. To identify the extent to which policy and planning related climate change adaptation initiatives were being considered and/ or implemented in SEQ; and
2. To identify existing gaps in climate change adaptation across the region.

An initial suite of preliminary adaption options was then selected for testing against the scenarios in the second series of workshops (see Low Choy et al 2012). In parallel, stakeholder feedback was also obtained through a series of interviews with key practitioners from state government, local government, non-government organisations, the private sector and peak bodies. These interviews aimed to increase sectoral understanding of the policy process within government and non-government organisations, including policy development and implementation with implications for climate change adaptation. A further selection of the preliminary adaption options was then distributed to additional stakeholder groups and organisations to gather further feedback through survey (see Low Choy et al 2012). At this point, the adaptation options were presented to a special workshop of the Project Reference Group (PRG) to gain their feedback and endorsement of the process and its outputs.

The full stakeholder engagement process and its achievements have previously been described (see Chapter 4). The Human Settlements team has drawn from the feedback from all of these stakeholder engagement sources to revise, modify, enhance and update the final selection of adaptation options.

The full context of this particular stakeholder engagement process that has been associated with the development, assessment and refinement of the adaptation options, is illustrated in Figure 5 as a series and sequence of steps that were completed by the Human Settlements team. Central to the process was the independent development of sector specific adaptation options which was coordinated by an agreed development and testing process previously described (see Figure 4) and, importantly, a consistent approach and format for the adaptation options. Figure 5 illustrates the principal sources and all of the inputs into this process of adaptation option development and assessment, namely the stakeholder engagement elements (e.g. workshops, interviews, surveys, PRG).

The other key element of the Human Settlements approach was the effort devoted to internal review and synthesis of adaptation options. This centred on a number of team retreats and workshops. They were crucial in: developing a mutually agreed methodology; consistent approaches in terms of policy frameworks and format for the adaptation options; identifying overlaps, duplication and gaps; and, importantly, the links between the programs and actions of various options. It was through this iterative process that cross sectoral adaptation options were identified and developed.

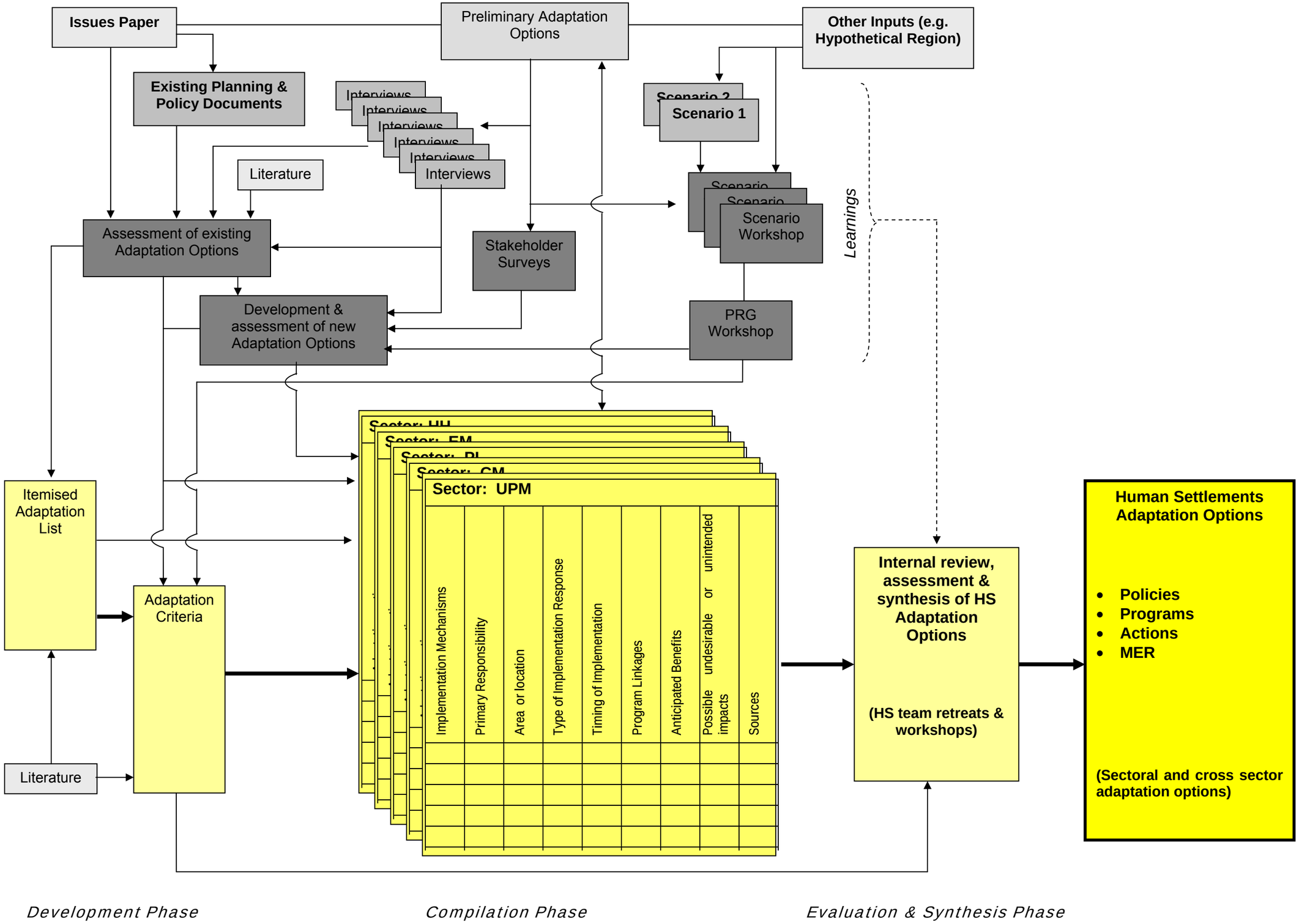


Figure 5: Development & Synthesis of Climate Change Adaptation Options for the Human Settlements Component

An overarching policy framework characterises each sector. In the following chapter, each sector's policy framework is described by a brief narrative supported by a diagrammatic representation of that framework. Respective frameworks are theoretically underpinned by a dominant conceptual schema derived from the literature or arranged to address the pragmatic focus of that particular sector. The framework comprises a series of policies with each policy supported by a number of programs. The implementation details of individual programs have been developed in terms of their respective sets of individual implementation actions.

Each policy is explained by a policy statement and supporting implementation details that identify:

- implementation mechanisms (e.g. regulatory, educational, incentive etc);
- primary responsibility for the policy and its implementation (plus associated responsibility/ies);
- the area or location where the policy has relevance;
- anticipated benefits of the policy;
- possible undesirable or unintended impacts from the policy; and
- citation of source/s for the policy (including modified forms of the policy) or a statement of its originality.

Programs were similarly developed with their distinguishing attributes being:

- implementation mechanisms (e.g. regulatory, educational, incentive etc);
- primary responsibility for the program and its implementation (plus associated responsibility/ies);
- the area or location where the policy has relevance;
- the type of implementation response (e.g. one-off, ongoing, episodic);
- timing of implementation (e.g. immediate, deferred);
- program linkages (coupling); and
- citation of source/s for the policy (including modified forms of the policy) or a statement of its originality.

Individual actions were grouped into implementation sets under each program and distinguished in terms of:

- implementation mechanisms (e.g. regulatory, educational, incentive etc);
- primary responsibility for the action and its implementation (plus associated responsibility/ies);
- type of implementation response (e.g. one-off, ongoing, episodic);
- program linkages (coupling); and
- citation of source/s for the policy (including modified forms of the policy) or a statement of its originality.

Specific implementation criteria were also derived for each action, including:

- key performance indicators;
- opportunities for monitoring and evaluation (e.g. existing review cycles); and
- primary responsibility for the implementation of the action (plus associated responsibility/ies).

Whilst the strength and appropriateness of selected adaptation options were tested through the scenario planning workshop process with stakeholders, further testing and evaluation was undertaken by some sectors of the Human Settlements team through their internal multi-criteria appraisal assessment processes. Each policy and program has been evaluated against the four 'What If' questions and the adaptation options evaluation criteria. This was the same assessment process undertaken by stakeholders as part of the adaptation option testing during the scenario workshops (see Low Choy et al 2012). The first step involved an assessment of the policies and programs of each adaptation option in terms of four 'What If' questions, namely:

1. What is the likelihood that it will have negative impacts on society?
2. To what extent does it represent 'value for money' (cost effectiveness)?
3. What is its likelihood of success (achieving aims)?
4. To what degree does it promote rather than inhibit resilience[4]?

Responses to these 'What If' questions were in terms of how well the option would perform to the particular question (i.e. on a scale of 'low', 'medium' or 'high' degree of conformance).

For the second step, a further and comprehensive assessment of the policies and programs of all adaptation options was undertaken using the same set of 'climate change adaptation options appraisal criteria' for human settlements that was employed in the scenario planning workshops. The full description of the 'climate change adaptation options appraisal criteria' is contained in Appendix C.

The adaptation appraisal criteria were developed by the Human Settlements team from the literature (see Low Choy et al 2012). This initial set of appraisal assessment criteria was then confirmed by the PRG in terms of their relevance and appropriateness. The criteria, whilst not exhaustive, comprise a benchmark to guide policy formulation for climate change adaptation. They represent well-established criteria that should assist to ensure that adaptation options are designed to deal with uncertain future climatic and socio-economic conditions, do not lead to unintended negative impacts on other systems, sectors or groups, enhance current policies and initiatives, do not increase the impacts from climate change and do not lead to maladaptation. The final set of 11 criteria along with an explanation of each is set out below:

- *Flexibility* - flexible adaptation options will be more responsive and flexible to changing future conditions, can be modified or adapted, will allow for adjustments due to unforeseen changed conditions and can be implemented with flexibility (Fankhauser et al 1999; Hallegatte 2009; UKCIP 2012).

[4] Resilience was defined for participants as follows:

- *"Resilience is the capacity of a system to absorb disturbance to undergo change and still retain essentially the same function, structure and feedbacks."* (Walker & Salt 2006:31);
- *"Resilience reflects the degree to which a complex adaptive system is capable of self-organization (versus lack of organization or organization forced by external factors) and the degree to which the system can build capacity for learning and adaptation."* (Adger et al 2005:1036)

- *Robustness* – robust adaptations can operate and perform under a wide range of uncertainties and future climatic scenarios. They are therefore not dependent on any particular future scenario.

- *Equity* – this is a critical dimension, as it is generally recognised that the poorest and most vulnerable groups will disproportionately experience the negative impacts of climate change and that adaptation options can have negative spill-over effects (Adger et al 2005; Adger et al 2009).

- *Coherence/synergy – alignment* – it is important to consider the interaction and alignment between an adaptation option and other policies, measures and sectors to ensure the implementation of the adaptation option does not negatively affect other policies or sectors and thus lead to sub-optimal results (Hallegatte 2009).

- *Coherence/synergy – enhancement* – adaptation options should also seek to enhance and strengthen the outcome of existing policies and initiatives.

- *Acceptability (political, bureaucratic, community and private sector)* – the acceptability of an adaptation option by different stakeholders is a critical factor that will influence the successful uptake, implementation and outcome of the adaptation option.

- *Avoidance of maladaptation* – Barnett & O'Neill (2010) define five types of maladaptation which we use here as criteria to assess adaptation options:
    - *Low greenhouse gas emissions* – the future emissions and energy costs of adaptation options need to be taken into account, as energy intensive adaptation options will create a positive feedback by increasing greenhouse gas emissions and thus contributing to climate change and increasing the level of adaptation required.
    - *Less vulnerable populations* – adaptation actions need to ensure they do not meet the needs of one group or sector while disproportionately burdening those most vulnerable.
    - *Low opportunity costs* – adaptation options need to ensure they do not lead to high environmental or social costs relative to alternative options.
    - *Adaptation incentives* – adaptation options must not reduce incentives to adapt by encouraging dependence on others or penalising anticipatory action.
    - *Low path dependency* – adaptation options must not result in trajectories that are difficult to change in the future, lead to decreased flexibility to respond to unforeseen changes and therefore limit choices available to future generations.

Specifically, the assessment addressed the following question: *'How well will the adaption option address expected climate change in SEQ in terms of the climate change adaptation options appraisal criteria'*. Each adaptation option was assessed in terms of how well it met each of these eleven appraisal criteria, i.e. either 'high' or 'low', where 'high' was considered favourable and 'low' unfavourable.

On the question of an economic analysis of the various adaptation options, it was concluded that in view of difficulties in quantifying and measuring the various forms of adaption options and their policies and programs, as well as their associated externalities; the potential unintended consequences; likelihood of autonomous adaptation and the like; a cost and benefit analysis would not be attempted. A fuller discussion on the issues related to an economic evaluation of adaptation options is contained in Low Choy et al (2012). Noting these constraints, many of the issues associated with a traditional economic analysis were in fact explored with stakeholders in a qualitative sense through the scenario planning process.

In total, across the Human Settlements component, some 21 policies, 95 programs, and 498 actions have been developed. A summary distribution of policies, programs and actions across the five human settlement sectors is provided in Table 6.

Table 6: Summary of Policies, Programs & Actions Developed in the Human Settlements Sectors

Sector	Policies	Programs	Actions (Implementation)	Actions (Monitoring & Evaluation)
Urban Planning & Management	3	43	252	252
Coastal Management	5	11	46	46
Physical Infrastructure	3	9	58	58
Emergency Management	6	19	65	65
Human Health	4	13	77	77
Total	**21**	**95**	**498**	**498**

These policies, programs and actions are introduced and summarised in subsequent sector specific sections of the following chapter. A more detailed summary of each sector's adaption options is contained in Appendix D with the full description of the policies, programs and actions of all adaptation options contained in the accompanying Supplementary Report.

Overall within each sector, each program and their respective actions have been classified under eight adaptation themes based on key messages elicited from stakeholder feedback (Low Choy et al 2012), document analysis and literature review. These include:

- Preparing the Community
- Support for Vulnerable Communities
- Leadership, including Community Leadership
- Proactive (Anticipatory) Initiatives
- Managing the (Urban) Environment
- Technological Development and Innovation
- Risk Communication
- Training and Education

These broad themes commence the synthesis process and provide a sense of possible key strategic programs that could be contemplated to assist in climate change adaptation in the region.

The following chapter provides individual sector specific outlines of their respective adaptation options frameworks, the rationale for the framework, commentary on implication of not adopting the adaptation options, a review of sector specific research questions and recommendations for further research in that sector.

10.0 HUMAN SETTLEMENTS ADAPTATION OPTIONS

10.1 Urban Planning and Management

10.1.1 Introduction

The planning process encompasses regional and local planning instruments which configures urban form and function. In Australia, the planning process is largely in the hands of state and local governments (Murphy 2007) and is implemented through a series of statutory and non-statutory instruments such as plans, strategies and policies. Adapting to climate change will incur many challenges and demand a rethink in the way in which our cities and towns are planned and built; thereby planning plays an important part in safeguarding communities against future climate change impacts, particularly through adaptation (Bulkeley 2006).

Urban planning and management in SEQ is confronted with multiple challenges when considering adaptation to climate change impacts. On the one hand, urban planning must attend to the task of adapting new developments to the predicted impacts of climate change; and on the other hand, urban planning and management must have regard to the redevelopment and/or retrofitting of existing settlements. The decision-making process in the region is also likely to be challenged when establishing mandatory and/ or voluntary adaptation, engaging the non-government sector and identifying and overcoming legal and other barriers to climate change adaptation such as scale and uncertainty, capability and resources, and effective communication and engagement with stakeholders. The adaptation options proposed for the urban planning and management sector take into consideration these challenges to enable the planning process to improve climate change adaptation across the region.

10.1.2 Framework Rationale

The overarching framework for the urban planning and management adaptation options acknowledges those planning challenges that are traditionally undertaken in two distinct geographical contexts – inland and coastal areas.

The framework is structured using an overarching goal, three policies and a series of discrete programs and actions. Policy 1 addresses the coastal environment and Policy 2 deals with the inland environment. Both are directly related to the statutory and non-statutory planning system currently in place in SEQ with a focus on both existing and new settlements. Policy 3 deals specifically with adaptive capacity as this is seen as a necessary condition to improve the planning decision-making

process for climate adaptation to occur at both local and regional scales. These three policies reinforce the role of the planning process in reducing the vulnerability of SEQ's settlements to climate change impacts, including natural hazards in both coastal and inland settlements.

The adaptation options framework provides a clear distinction between programs that are to be implemented through statutory and/or non-statutory channels depending on the climate change related issues they aim to address. It is important to note that some of the programs are best implemented through statutory channels to improve their outcomes and effectiveness[5] in reducing SEQ's vulnerability to climate change impacts. In total, there are 43 programs of which 20 have statutory status, 16 have a non-statutory status and 7 have an optional statutory or non-statutory status (see Figure 6).

10.1.3 Formulation of Adaptation Options

The formulation of adaptation options was informed by a document analysis of existing adaptation related initiatives in association with a literature review and feedback from key stakeholders. The document analysis for the urban planning and management (UPM) sector focused on existing planning initiatives at the state, regional and local scales and selected case study areas, including state-wide policies and plans, regional plans and policies, local planning schemes, local strategies, plans and programs directly or indirectly related to climate change adaptation (see Appendix B for a full list of documents and their analysis). The purpose of this analysis was two-fold: (i) to identify the extent to which planning related climate change adaptation initiatives were being considered and/ or implemented in SEQ; and (ii) to identify existing gaps in climate change adaptation across the region. This analysis was further complemented by a literature review on climate change adaptation in the planning sector elsewhere in Australia and overseas. In parallel, stakeholder feedback was obtained through a series of interviews with key practitioners from state government, local government, non-government and community based organisations, and private sector. These interviews provided key insights into the policy and decision-making process, key internal and external barriers, and assisted with the development of climate adaptation options. A selection of adaptation options was then tested against scenarios at the second series of stakeholder workshops and distributed to additional stakeholder groups to gather further feedback (see Low Choy et al 2012).

[5] Effectiveness is understood here in the context proposed by Adger et al (2005: 81) which suggests that adaptation actions are effective when they achieve their proposed objectives.

Overarching Goal: Establish adaptation strategies within statutory and non-statutory planning processes to minimise the region's vulnerability and risks from climate change impacts, including the changing nature and/or intensification of natural hazards.

Key words: urban planning and management, coastal landscapes, inland landscapes, adaptive capacity

Policy 1. The statutory and non-statutory planning processes must seek to minimise the vulnerability of coastal landscapes to storm tide and sea level rise inundation, coastal erosion, cyclones and severe winds, severe storms and hail, and flooding.

Program 1.1 Consolidation of urban development: Urban development is consolidated by favouring infill and redevelopment of existing urban areas to minimise the extent of development occurring in highly vulnerable coastal areas.
Program 1.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.
Program 1.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to coastal hazards.
Program 1.4 Building code design criteria: Building codes are reviewed to incorporate design criteria for buildings to resist future loads that may result from the impact of climate change-exacerbated hazards during a minimum service life of 50 years.
Program 1.5 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to reduce or eliminate damage caused by flooding as a result of sea level rise and coastal storm surge events.
Program 1.6 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to receding shorelines are sited landward and/ or relocated.
Program 1.7 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure.
Program 1.8 Coastal defence: Coastal defence mechanisms are implemented to provide continuing flood and erosion risk management due to storm tides and sea level rise.
Program 1.9 Hazards full disclosure clause: A Coastal Hazards Full Disclosure Law is implemented to alert buyers of coastal properties about current and future climate related risks such as erosion rates, storm history, inundation and sea level rise.

Program 1.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/or equipped with back-up systems.

Program 1.11 Innovative design for coastal areas: Innovative engineering and design solutions are employed to manage coastal hazards in low risk areas.
Program 1.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.
Program 1.13 Protection of coastal habitats: Areas that provide for the landward retreat of coastal habitats and species at risk from predicted sea level rise are identified and protected.
Program 1.14 Long-term (strategic) planning: Planning and decision-making consider the potential implications of climate change over the life of long-term assets (100 year planning horizon).

Program 1.15 Coordinated response to sea level rise: A coordinated response to sea-level rise is initiated to develop measures related to coastal defence, accommodation and planned retreat.
Program 1.16 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.

Program 1.17 Coastal erosion risk minimisation: A coastal erosion preparedness and awareness scheme is initiated to minimise risks from coastal erosion, including climate change projections, in vulnerable areas.

Program 1.18 Coastal inundation risk minimisation: A coastal inundation preparedness and awareness scheme is initiated to minimise coastal inundation risks, including climate change projections, in vulnerable areas.
Program 1.19 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Policy 2. The statutory and non-statutory planning processes must seek to minimise the vulnerability of inland landscapes to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.

Program 2.1 Consolidation of urban development: Infill development is consolidated in existing urban areas while avoiding areas with high exposure to flooding and bushfire.
Program 2.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.
Program 2.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to climate change impacts.
Program 2.4 Building code design criteria for floods: Building codes are reviewed to ensure building structures withstand projected site-specific flood levels.
Program 2.5 Building code design criteria for bushfire: Building codes are reviewed to ensure building structures are more resilient to bushfires.
Program 2.6 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to improve adaptation to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.
Program 2.7 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to floodplains are sited landward and/ or relocated.
Program 2.8 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure.
Program 2.9 Hazards full disclosure clause: A Hazards Full Disclosure Law is implemented to alert buyers of properties about current and future climate related risks associated with flooding, including riverine and flash floods, and bushfire.

Program 2.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/ or equipped with back-up systems.

Program 2.11 Innovative designs for floods: Innovative engineering and design solutions are employed to minimise vulnerability to flooding in low risk areas.
Program 2.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.
Program 2.13 Mapping of flood vulnerable areas: A program is created to map and catalogue developed building sites that are flooded three or more times over a 10 year-period.

Program 2.14 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.

Program 2.15 Flood risk minimisation: A flood preparedness and awareness scheme is initiated to minimise both flash flood and riverine flood risks, including climate change projections, in flood prone areas.
Program 2.16 Bushfire risk minimisation: A bushfire preparedness and awareness scheme is initiated to minimise bushfire risks, including climate change projections, in bushfire prone areas.
Program 2.17 Heatwave risk minimisation: A heatwave preparedness and awareness scheme is initiated to minimise heatwave risks, including climate change projections, in heatwave prone areas.
Program 2.18 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Policy 3. SEQ's planning processes must have strong adaptive capacity to improve decision-making to adapt to climate change.

Program 3.1 Leadership development: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Program 3.2 Capacity building: Local governments' capacity must continue to be built through improved knowledge and skills about climate change.
Program 3.3 Risk communication on climate change: Communication of climate change risks to decision-makers and wider community (flooding, storm surge, heatwave and sea level rise) must be improved.

Program 3.4 Risk allocation mechanisms: Climate change risks must be incorporated into decision-making processes.

Program 3.5 Professional and sub-professional education and training: A mandatory training program is created to educate professionals and sub-professionals in relevant fields (e.g. planning, architecture, surveying, building certification, real estate agents, engineering, and construction management) on the need to incorporate adaptation to climate change and natural hazards as a basis for establishing design criteria for new infrastructure and housing estates.

Program 3.6 Anticipatory planning response: The vulnerability of existing settlements in SEQ to climate change-exacerbated hazards, including natural hazards must be reduced through pro-active action.

Statutory planning
Non-statutory planning
Non-statutory and/or statutory planning

Figure 6: Urban Planning and Management Adaptation Options Framework

A series of discrete actions were generated for each of the 43 programs to provide further details on implementation, monitoring and performance evaluation (see Appendix D1). Overall, programs and their respective actions are classified under the eight adaptation themes (previously discussed), that were drawn from stakeholder feedback, document analysis and literature review (see Table 7).

Table 7: Distribution of UPM programs across adaptation themes

Adaptation Theme	Program No.	Program
Preparing the Community	1.17 1.18 1.19; 2.18 2.15 2.16 2.17	Coastal Erosion Risk Minimisation Coastal Inundation Risk Minimisation Urban Parks and Open Spaces Flood Risk Minimisation Bushfire Risk Minimisation Heatwave Risk Minimisation
Support for Vulnerable Communities	1.3; 2.3 1.6; 2.6	Community Planning Retrofitting of Residential Properties
Leadership, including Community Leadership	3.1	Leadership Development
Proactive (Anticipatory) Initiatives	1.7; 2.8 1.14 1.15 1.16; 2.14 3.6	Strategic Relocation and Upgrade of Essential Emergency and Health Services Long-Term (Strategic) Planning Coordinated Response to Sea Level Rise Land Use Conversion Anticipatory Planning Response
Managing the (Urban) Environment	1.1; 2.1 1.2; 2.2 1.4 1.6; 1.7 1.8 1.10; 2.10 1.13 2.4 2.5 2.13	Consolidation of Urban Development Infrastructure Sites Building Code Design Criteria Planned Retreat Coastal Defence Redundancy and Back-Up for Essential Services and Buildings Protection of Coastal Habitats Building Code Design Criteria for Floods Building Code Design Criteria for Bushfire Mapping of Flood Vulnerable Areas
Technological Development and Innovation	1.11 1.12; 2.12 2.11	Innovative Design for Coastal Areas Flood Immunity Innovative Designs for Floods
Risk Communication	1.9; 2.9 3.3 3.4	Hazards Full Disclosure Clause Risk Communication on Climate Change Risk Allocation Mechanisms
Training and Education	3.2 3.5	Capacity Building Professional and Sub-Professional Education and Training

The document analysis revealed that climate change adaptation related initiatives are being implemented at the state, regional and local scales in SEQ (see Appendix B). This was also confirmed through stakeholder feedback in which state and local government agencies appear to accept that existing policy documents are sufficient to address climate change (Low Choy et al 2012). These initiatives are incorporated in the proposed programs and actions under the following adaptation themes:

Support for Vulnerable Communities ('Community Planning'); Leadership, including Community Leadership; Proactive (Anticipatory) Initiatives ('Long-term [Strategic] Planning'); Managing the [Urban] Environment ('Consolidation of Urban Development'); Risk Communication ('Risk Allocation Mechanisms').

Specific programs were also designed to address some of the key messages from stakeholders (Low Choy et al 2012). These include the need for *strong leadership* ('Leadership Development'); *improved coordination and cooperation* ('Capacity Building' and specific actions in 'Coastal Erosion Risk Minimisation', 'Coastal Inundation Risk Minimisation', 'Flood Risk Minimisation', 'Bushfire Risk Minimisation', 'Heatwave Risk Minimisation', 'Community Planning', 'Retrofitting of Residential Properties', 'Strategic Relocation and Upgrade of Essential Emergency and Health Services', 'Redundancy and Back-Up for Essential Services and Buildings', 'Planned Retreat', 'Mapping of Flood Vulnerable Areas', 'Risk Communication on Climate Change' and Risk 'Allocation Mechanisms'); *improved community engagement* (specific actions in 'Community Planning', 'Anticipatory Planning Response', 'Strategic Relocation and Upgrade of Essential Emergency and Health Services', 'Planned Retreat' and 'Hazards Full Disclosure Clause'); *injurious affection* (specific actions in 'Land Use Conversion' and 'Anticipatory Planning Response'); and the need for *further research*/*information* (specific actions in 'Coastal Erosion Risk Minimisation', 'Coastal Inundation Risk Minimisation', 'Flood Risk Minimisation', 'Bushfire Risk Minimisation', 'Heatwave Risk Minimisation', 'Community Planning', 'Retrofitting of Residential Properties', 'Anticipatory Planning Response', 'Strategic Relocation' and 'Upgrade of Essential Emergency and Health Services', 'Redundancy and Back-Up for Essential Services and Buildings', 'Consolidation of Urban Development', 'Infrastructure Sites', 'Planned Retreat', 'Flood Immunity', 'Mapping of Flood Vulnerable Areas' and 'Capacity Building').

10.1.4 Implications of not adopting Adaptation Options

SEQ's vulnerability to climate change impacts has been well documented in recent years (Hennessy et al 2007). This is mostly due to ongoing population growth and the geographical location and distribution of its human settlements across the region. SEQ, like many parts of Australia, also inherits a legacy of earlier planning decisions and land use commitments based on expected historical return periods of weather events which has placed and continues to place development in many hazardous areas such as floodplains (McDonald et al 2010). Additionally, the regional coastline has been extensively modified to accommodate a number of urban centres and their major supporting infrastructure, such as regional and international airports. The coastal urban centres also include large areas of residential canal estates as well as traditional residential areas ranging from low to high density (Low Choy et al 2010).

The location of existing infrastructure and settlements in areas highly exposed to the projected impacts of climate change places those buildings and assets, and the people who live or work in them, at increased risk of harm (McDonald et al 2010). For instance, in SEQ, 75% of the 200,000 properties built pre-1960 are located within 10 km of the coast and could be subject to coastal hazards, such as sea level rise and storm surges (Wang et al 2010). The recent 2011 floods confirmed the region's vulnerability to extreme weather events also in non-coastal areas and identified the role state and local planning instruments have in managing associated risks (Queensland Floods Commission of Inquiry 2012). For example, initial assessments indicated that flood estimates based on the probability-based design

flood event Q100 needed to be review as the events from 2011 provided new data on flood dynamics in the Brisbane River catchment area (Brisbane City Council 2011).

Consequently, it is critical that the adaptation options proposed, in the form of policies, programs and actions for the UPM sector, are implemented to minimise SEQ's vulnerability to future climate change impacts, including natural hazards. The lack of implementation of these adaptation options will continue to place the region, its settlements and population at risk. Furthermore, it could also lead to significant economic, social and environmental losses with further consequences for both the region's liveability and sustainability.

10.1.5 Review of Research Questions

The UPM sector focused on identifying and developing climate change adaptation options to inform local and regional statutory and non-statutory planning processes in SEQ. This included: (i) investigating the most appropriate planning framework and scale to address climate change adaptation; (ii) investigating how collaborative planning and management can facilitate the development and implementation of climate change adaptation, including the identification of key stakeholders and how they relate to the implementation and governance of climate adaptation; and (iii) investigating how current institutional arrangements might be remodelled to support climate change adaptation. The UPM sector also explored the synergies and trade-offs between climate change adaptation and mitigation in the management of urban and regional areas.

Research findings indicate that adaptation actions are already in place in SEQ, albeit, limited. These include existing initiatives at the local and regional scales that deal with risks related to natural hazards such as floods. This is the case of the SEQ Regional Plan, local planning schemes and State Planning Policies. However, the recent 2011 floods revealed that in many locations these existing measures were not sufficient as they were not able to deal with the intensity of that event (Queensland Floods Commission of Inquiry 2012). Other existing adaptation actions related to stronger leadership and proactive action are also proposed by some local authorities but they lack statutory powers to be implemented effectively (e.g. Climate Adaptation Strategies proposed by some local authorities).

The planning scale (temporal or spatial - macro or micro) is understood as having a central role in minimising the levels of exposure and vulnerability of human settlements to the impacts of a changing climate (Lindley et al 2006). SEQ has a plurality of landscapes that are multi-scalar having spatial, temporal and modification dimensions. The spatial dimension encompasses distinct physical units that are rationally and intuitively recognised as being a national, regional or local unit. The temporal dimension involves past, present and future features of the landscape that takes into account the on-going relationship between humans and the landscape and how these features are conserved or spoilt for future generations. Last, the modification dimension encompasses the transformations and rehabilitations that have occurred in the landscape shaping it into urbanised areas, agricultural fields or conservation areas and the like. These dimensions provide the ability to incorporate future changes in the landscape, especially anticipating the consequences that climate change impacts will have on human settlements (Selman 2006). Currently,

across SEQ there are adaptation initiatives being implemented at both state and local scale, however, they are not advanced in terms of adopting an approach that includes social, cultural and biophysical dimensions beyond traditional political and administrative boundaries, and they do not promote cross-scalar and cross-sectoral integration (Low Choy et al 2010).

Urban planning authority and capability in Australia is largely in the hands of state and local governments (Murphy 2007). Nevertheless, while state governments have a critical role given their powers, it is at local government and community scale that climate adaptation will mostly occur (Measham et al 2011). This interplay between government levels generates two key barriers to effective adaptation as outlined by stakeholders (Low Choy et al 2012). The first relates to the matter of injurious affection and associated responsibilities and accountabilities when dealing with climate change risks which has been identified to hinder the implementation of a number of adaptation options. This barrier is directly related with the second one which calls for strong leadership for climate adaptation in the region. The matter of injurious affection will only be solved if it is dealt by the state government with support from local government (Low Choy et al 2012). However, there is also need for strong leadership to improve the communication about climate change risks in the region as well as establishing planning horizons and decisions that go beyond the duration of electoral cycles. Additionally, the lack of scientific knowledge and certainty in climate science continues to be identified as a barrier to effective adaptation and delaying the implementation of more robust measures. This emphasises the need for research and capacity to continue to be built across the region to improve climate adaptation.

The issue related to injurious affection reveals that current regulatory arrangements and responsibilities for the management of human settlements in SEQ need to be reviewed. A review of current institutional and policy arrangements is also needed to improve better coordination and collaboration between government agencies, industry and communities across the region which comprised a key message from stakeholders (Low Choy et al 2012).

Research findings also identified critical links between sectors that must be improved to enable effective adaptation. A good example is the need for better integration between urban planners and managers and emergency managers, particularly at the local level to ensure planning decisions do not exacerbate climate change impacts and increase the vulnerability of communities. Additionally, it is also important to identify links within sectors to map synergies and trade-offs between mitigation and adaptation options. For example, urban consolidation in SEQ has been advocated to occur through compact settlement (Department of Infrastructure and Planning, 2009), however this strategy could lead to potential trade-offs as energy consumption could increase to support higher density nodes as well as exacerbate urban heat island effects (Serrao-Neumann et al 2011).

Furthermore, stakeholders indicated that it is essential that continuing financial and non-financial support for capacity building is provided to enhance communities' ability to deal with climate change and associated future change. This is in terms of both the continuity and longevity of initiatives, including awareness and educational programs and campaigns which need to be of high quality, specific to groups and

audience, inclusive of vulnerable groups and presented in non alarmist terms to avoid negative messaging (Low Choy et al 2012).

In terms of the role of the private sector in promoting adaptation, whilst there are calls to reduce regulation, increase the flexibility of the planning system and allow market forces to determine appropriate adaptation responses (Low Choy et al 2012), it is important to define clearer responsibilities to avoid increasing the vulnerability of places. In this context, it is important to establish discussions with the private sector, particularly the land development, property and insurance industries to achieve alternative solutions to deal with future climate change impacts (Taylor et al 2012).

As outlined earlier, adaptation options for the UPM sector need to be implemented through statutory and/or non-statutory channels facilitated by a number of mechanisms, particularly regulations, policies, advice, guidelines and financial and non-financial incentives. For example, adaptation options that deal with Managing the (Urban) Environment such as 'Consolidation of Urban Development' and 'Hazards Full Disclosure Clause' need to have statutory powers to be effective. Conversely, other adaptation options related to 'Preparing the Community' could be effective if implemented through non-statutory channels such as financial and non-financial incentives. By using a combination of statutory and/or non-statutory channels when implementing adaptation options, the UPM sector could promote both mandatory and/ or voluntary adaptation.

10.1.6 Recommendations for Future Research

This research also identified two *problématiques* that require future studies. The first is the need to understand how improved coordination of adaptation decision-making across sectors can best support successful collective action. Given the 'wicked' nature of the problem posed by climate change (van Bueren et al 2003), the second relates to assessing how lessons learned about effective climate adaptation at the local level can be transferred to other locations and contexts. Such lessons can only be extracted once proposed adaptation options are implemented, monitored and reviewed, thereby requiring long-term longitudinal studies.

10.2 Coastal Management

10.2.1 Introduction

Coastal management is the combination of human processes and actions to manage the interaction between human settlements and natural processes within the coastal zone. These may include the dynamics of tidal waters, biogeochemical cycles and ecosystems functions, interacting with human settlements in a number of ways. Here the focus is on the impact of water dynamics processes such as waves, storm tides and sea level rise on sandy shores and waterways, both natural and artificial, and their interaction with buildings and infrastructure, considering both the current situation and future sea level rise scenarios. The aim is to reduce the risk to human settlements by identifying a set of adaptation options to manage storm tide inundation and erosion, while maintaining the natural functions of coastal

ecosystems. When defence of current urban forms and buildings is not feasible, adaptation should be reached by innovative designs able to cope with coastal hazards or, in some cases, by retreating from areas at risk.

10.2.2 Framework Rationale

Adapting SEQ's coastal settlements to the risk of current and future coastal hazards is the overarching principle behind the development of policies, programs and actions for coastal management. This principle is pursued by combining adaptation options to manage coastal erosion and floods with hard and soft defence infrastructure, planned retreat from areas at risk or changing design and improve resilience of buildings and infrastructure to accommodate floods. In addition, a specific policy is proposed to increase the capacity of coastal communities and institution to adapt to climate variability and change, including sea level rise.

The adopted framework *Defend/Retreat/Accommodate* is widely used for coastal planning considerations (e.g. Eurosion 2005) and is presented here as a set of sub-principles for a range of coastal management policies, programs and actions. These are presented to decision-makers as alternative ways of dealing with current and future coastal hazards in SEQ. In addition, a *Capacity Building* sub-principle encloses a range of policies, programs and actions designed to improve the capacity of coastal communities and institutions to manage SEQ shorelines in a changing climate.

10.2.3 Formulation of Adaptation Options

In general, local authorities may choose to adopt a combination of different policies for a given coastal stretch. For instance, developed areas or critical infrastructure can be defended from storm tides by combining a suite of actions to avoid inundation; less developed areas threatened by erosion can use planned retreat as a long term policy to absorb the impacts of sea level rise; innovative design standard can allow the accommodation of floods and reducing the damages to properties and infrastructure. A more detailed explanation of the terms defend, retreat, accommodate and capacity building is provided below.

Defend refers to maintaining the current position of the shoreline and minimising the impact of chronic and extreme erosion and the probability of occurrence of storm tide floods. In some cases local authorities may find it convenient to defend the current shoreline position and protect physical and natural assets from erosion and flooding. In this case, a defence approach should be based on the combination of soft and hard engineering options. These may include erosion and flood control structures (e.g. groynes, breakwaters, seawalls, sea dikes) and soft engineering interventions (e.g. beach nourishment, dune construction and generation, wetland restoration). This approach can have different aims, which should be determined based on local specificities and decisions. Policies under the Defend sub-principle are related to (i) preparing sandy shorelines for future coastal erosion and (ii) avoiding inundation from current and future storm tides.

Retreat refers to gradually removing dwellings and infrastructure from areas at risk. Local authorities may choose to retreat to safer areas by applying a combination of land planning policies and actions with consequential environmental restoration to

free space and devolve natural functions. Options to retreat may include land purchase and resumption, land swap, land surrender, changing land-use, development setbacks and rolling easements. These options may be implemented in a voluntary or mandatory manner. The policy designed to pursue relocation is focused on retreating from vulnerable shores when defence is not feasible in the future.

Accommodate refers to the improvement of the design standards for dwellings and infrastructure to reduce the damage caused by occasional floods. Accommodation approaches are more relevant for managing occasional floods than continuous coastal recession and permanent inundation. Accommodation approaches may include retrofitting existing dwellings and infrastructure and the provision of new design standards minimizing damages caused by storm tide floods. As a consequence, the policy formulated for accommodation, focuses on the design of coastal settlements in flood prone areas to accommodate current and future storm tides.

Capacity building refers to actions designed to improve the adaptive capacity of coastal communities and institutions to cope with climate risks. This may include creating community programs for coastal restoration, such as beach care or dune care; promoting coastal hazards education programs for schools; and design training programs for council officers dealing with planning and management in coastal areas.

The range of adaptation options, presented in the form of policies, programs and actions, and framed within the overarching principles presented above, were identified through a document analysis and a literature review of existing approaches and by consulting with coastal experts and stakeholders in SEQ. These adaptation options deal with coastal erosion and inundation through coastal defence (retaining the existing shoreline and avoid floods), planned retreat (relocate from areas at risk) or accommodation of floods (minimise the impacts of floods on settlements and infrastructure). These options were selected by taking into consideration the social, economic and environmental characteristics of the case study areas. Interviews with local stakeholders were carried out to better understand the implications of different options in a given context, and the elements relevant to adaptation important to them. In particular, it is acknowledged that the major constraint in implementing adaptation options is financial as many of these option imply building new structures for protection from extreme storms (e.g. storm tide barriers); upgrade existing infrastructure (e.g. seawalls to avoid erosion and inundation and water-proofing transport infrastructure, water and electricity supply networks and existing dwellings); or maintaining and improving the resilience of beaches and dunes. Future storms and floods may trigger new waves of investment. For instance, a cycle of storms, such as those of the 1960s and 1970s, may raise the attention of the public and push institutions to provide an adequate response. Also, it is possible that some parts of SEQ's hazard prone areas will be inundated more often in the future, especially under sea level rise. In this case, when defence becomes too costly, the initial actions may include upgrading the existing designs to accommodate extreme water levels, but in the longer term relocation might be the only answer, especially if the cost of defence infrastructure is higher than buying back land and properties. Public awareness and capacity of institutions were also raised as a barrier to

adaptation with an emerging need for specific engagement, education and training programs.

As a result, a set of possible adaptation options have been selected and expressed in terms of policies, programs and actions. They were analysed within a sophisticated decision-making framework that used a multi criteria appraisal assessment of each program and action and identifies possible implementation mechanisms, responsibilities, locations, timing and linkages with other sectors, including elements to monitor their effectiveness (see Chapter 9).

Policies, programs and actions are structured around the following options: beach nourishment, innovative erosion control structures, dune construction and regeneration, storm tide barriers and dykes, planning methods to implement planned retreat (e.g. rolling easement, coastal setbacks, land purchase, etc.), making space for water, community engagement and education programs and capacity building of institutions (see Figure 7).

The full range of specific programs and actions are summarised in the appendices of this report (see Appendix D2), and described in full in the accompanying Supplementary Report.

Overarching Goal: Adapt coastal settlements to the risk of current and future coastal hazards using a combination of programs involving defence, retreat and accommodation approaches while improving the capacity of coastal communities to adapt.

Key words: coastal management, defend, retreat, accommodate, capacity building

Defend

Policy 1. Sandy shorelines must be prepared for future coastal erosion events associated with climate variability and change.

Program 1.1 Beach nourishment in a changing climate: Instigate a program to defend the current position of the shoreline through erosion control involving a combination of beach nourishment, dune restoration and (re)construction, and hard coastal defences.

Program 1.2 Innovative erosion control approaches: Identify and assess innovative approaches to address coastal erosion, including hard structures, beach drainage and emerging technologies.

Program 1.3 Dunes restoration in a changing climate: Identify, restore and maintain coastal dune systems threatened by the impact of sea level rise and extreme erosion.

Policy 2. Coastal settlements must be defended from the risks of current and future storm tides which may be affected by climate variability and change.

Program 2.1 Storm tides defence system: Avoid inundation of vulnerable coastal communities under current and future storm tide events by combining hard and soft defence options to minimize the risk of storm tide inundation.

Retreat

Policy 3. Coastal settlements should retreat from vulnerable shores when defence is not feasible in the future and the natural functions of shores must be restored.

Program 3.1 Retreat from high coastal hazard areas: Develop innovative methods to retreat from areas at risk, including voluntary and compulsory mechanisms such as land swap, land purchase and resumption, land surrender, rolling easements and coastal setbacks to retreat from areas at risk from erosion and storm tides.

Program 3.2 Restoration of coastal environments: Remove buildings and infrastructure affected by erosion and inundation and those within retreat areas and restore ecosystem functions of beaches, dunes, wetlands and riparian environments.

Accommodate

Policy 4. Coastal settlement in flood prone areas must be designed to accommodate current and future storm tides.

Program 4.1 Space for water: New space should be identified to allow extreme water levels to be accommodated during storm tides.

Program 4.2 Design standards for buildings and infrastructure: Buildings and infrastructure designs can be improved to accommodate extreme water levels during storm tides. These changes should apply to new and existing buildings and infrastructure.

Capacity Building

Policy 5. The Capacity of the community and institutions to face current and future coastal hazards must be improved.

Program 5.1 Community capacity and engagement programs: Create capacity and engagement programs for coastal rehabilitation and restoration including programs for dunes and wetlands restoration.

Program 5.2 Enhanced coastal education Programs: Integrate climate adaptation into existing school education programs (primary and secondary levels).

Program 5.3 Enhanced institutional capacities to manage coastal hazards: Build capacity of council officers and other relevant organization to manage coastal hazard areas in a changing climate.

Statutory planning | Non-statutory planning | Non-statutory and/or statutory planning

Figure 7: Coastal Management Adaptation Options Framework

The abovementioned programs and their respective actions are also classified under the eight adaptation themes (see Table 8). These are based on key messages elicited by stakeholder feedback (Low Choy et al 2012), document analysis and literature review (see Table B1, Appendix B) and used across all Human Settlements sectors.

Table 8: Distribution of CM programs across adaptation themes

Adaptation Theme	Program No.	Program
Preparing the Community	5.1	Community Capacity and Engagement Programs
Support for Vulnerable Communities		n/a
Leadership, including Community Leadership		n/a
Proactive (Anticipatory) Initiatives		n/a
Managing the (Urban) Environment	1.1 1.3 2.1 3.1 3.2 4.1 4.2	Beach Nourishment in a Changing Climate Dunes Restoration in a Changing Climate Storm Tides Defence System Retreat from High Coastal Hazard Areas Restoration of Coastal Environments Space for Water Design Standards for Buildings and Infrastructure
Technological Development and Innovations	1.2	Innovative Erosion Control Approaches
Risk Communication		n/a
Training and Education	5.2 5.3	Enhanced Coastal Education Programs Build Capacity of Institutions to Manage Coastal Hazards

10.2.4 Implications of not adopting Adaptation Options

As highlighted in a number of recent reports (Department of Climate Change 2009; McDonald et al 2010; Wang et al 2010; Department of Climate Change and Energy Efficiency 2011) climate change in SEQ's coastal zone, in terms of sea level rise, changing wave climate patterns and heavier storm surges, is likely to lead to major impacts on the region's community, economy and environment. In SEQ the upper range of sea level rise is projected to be 0.2 m by 2030 and 0.5 m by 2070 (Wang et al 2010). However, recent research expects average sea levels to rise by up to 1.5 m at the end of this century (Rahmstorf 2012). As a general consequence, storm tides will reach higher levels, with a reduction of the return period of events. For instance, the current 1-in-100-year event will have a probability of occurring every 61 years by 2030, due to the additional water level of 0.2 m.

At present, it is estimated that about 227,000 persons in SEQ are at risk of inundation from a 1-in-100-year storm tide. Without considering a future increase in population in SEQ, sea level rise could see this number increase to 245,100 persons by 2030 and 273,000 persons by 2070 (Wang et al 2010). However, the number of coastal residents and tourists has grown to unprecedented levels in the last two decades and is projected to keep growing in the future, with the coastal lifestyle and

the ‘sea change’ phenomenon being major drivers for population growth. As a consequence, the region’s population is expected to increase from today’s 2.69 million to 4.4 million by 2030, compounding the impact of climate change if the population remains at its current pattern of settlement (Department of Infrastructure and Planning 2009).

Without adaptation, future populations may experience greater inundation damage. Currently in SEQ 35,200 residential buildings are exposed to a 2.5 m storm tide (approximately a 1-in-100-year event), risking structure and content damage of about $1.1 billion. By 2030, with an additional 0.2m of sea level rise (and with the same planning and building regulations as today) the number of residential buildings at risk from a 2.5 m storm tide could increase to about 61,500 and the costs would increase to about $2.0 billion. In 2070 this would affect approximately 121,000 residential buildings and cost about $3.9 billion (Wang et al 2010). In addition to damages to coastal settlements, other infrastructure and natural assets are likely to be exposed to extreme water levels and storms. These include defence structures, ports, harbours, beaches, dunes, wetlands and riparian corridors. These assets support a wide range of industries, in particular transport, fisheries, and tourism.

10.2.5 Review of Research Questions

The coastal management (CM) sector has responded to a set of sectoral research questions that was identified in the beginning of the project. This section summarises the finding for each of those RQs related with the coastal management sector.

1. What are the implications of climate change, including sea level rise and the variability of storms patterns, on the existing settlements and infrastructures?

A vulnerability assessment at the suburb level was carried out to characterise the exposure, sensitivity and adaptive capacity of coastal suburbs within SEQ (Low Choy et al 2010; Sanò et al 2010a; Crick et al 2012). A more detailed assessment was carried out on one of the identified hot spots on the Gold Coast (Sanò et al 2011). The assessments found that coastal suburbs across SEQ are vulnerable to climate change at a different degrees, depending on their elevation, geomorphology and on a range of socio-economic determinants. Detailed modelling determined that the current shoreline defence system would be insufficient to cope with storm tides in the future.

2. *What are the implications of climate change, including sea level rise and the variability of storms patterns, on the existing coastal policy framework at the different levels of government?*

The current administrative settings to manage SEQ coastal areas is threatened by the challenge of coastal erosion and storm tides, exacerbated by the impacts of sea level rise. To better understand these implications, an examination was conducted into the existing policy framework and how state and local government instruments are being adapted to climate change (Sanò et al 2010b). A metric was developed to understand the progress and quality of adaptation at the local scale, to benchmark local authorities against their efforts in reducing their vulnerability (Sanò et al 2011a, Sanò 2011b; Sanò et al in preparation). While a major effort in terms of adaptation

planning is under progress with the implementation of the provisions of the new *Queensland Coastal Plan* (Department of Environment and Resource Management 2012), the lack of an appropriate administrative and legislative framework at the state level to implement innovative solutions to defend, accommodate or retreat from the shore, was also identified as a risk.

3. What are the available adaptation options from a systems perspective, including engineering solutions, economic measures, improvement of the social adaptive capacity and the modification of the existing legal and administrative framework? How do these options interact?

A detailed literature review and stakeholder consultation provided the basis to identify and test a range of adaptation options to defend, retreat or accommodate coastal hazards into the future. These include regenerative options (e.g. beach nourishment), hard defence options (e.g. seawalls), new design standards and planning approaches (e.g. planned retreat). By using an investigative approach to assess options against future scenarios and a range of criteria, it has been possible to provide information about their suitability and mechanisms for implementation in the future (Low Choy et al 2012; Sanò et al 2012a, b). The available options identified by the research project are at the core of this report.

4. How can coastal communities be involved to build consensus around climate issues and to identify and assess adaptation options?

Stakeholder engagement has been the core of the whole Human Settlements research approach. The scenario planning techniques employed during the stakeholder workshops allowed selected coastal management adaptation options to be explored from a range of different perspective. They also highlighted the implications of current decisions on the future of human settlements on the coast. In this way, the scenario planning exercise that has involved a range of coastal stakeholders (see Chapter 5), has been an efficient tool to improve stakeholder understanding within and across sectors.

5. How does coastal management interact with urban planning, emergency management and human health issues?

The focus of coastal management is on the interaction between coastal-specific features and processes within human settlements. The connection between coastal management and urban planning is quite clear to the point where coastal management initiatives are carried out to manage the interaction between the coast and urban environments. On the other hand, the interaction with emergency management and human health issues is less explicit, but never-the-less equally important. Emergency management on the coast is related with extreme coastal events, such as storm tides. Human health has relations with coastal management when facilities (e.g. hospitals) are located within coastal hazard prone areas. The details of cross-sectoral relationships between policies, programs and actions are highlighted throughout the adaptation options of this report.

10.2.6 Recommendations for Future Research

Future research within the coastal management sector should focus on:

1. Understanding the implications of worst-case scenarios on coastal settlements and infrastructures, with implications for coastal management (e.g. simulation of a large cyclone crossing the region);
2. Expanding the research into the feasibility of innovative adaptation options within the Queensland context, such as the use of rolling easements;
3. Expanding the research into innovative approaches to defend eroding shoreline without armouring, such as large-scale nourishments (e.g. the *Sand Engine* in the Netherlands) and its implications to coastal environments; and
4. Investigating the implication of climate change on a broader range of costal processes, including wave climate and sediment transport rates, biogeochemical cycles and water quality, ocean acidification and ecosystems health.

10.3 Physical Infrastructure

10.3.1 Introduction

Infrastructure commonly refers to physical or intangible assets whose destruction or disruption would seriously undermine public safety, social order and the fulfilment of key government responsibilities. In Australia, the term critical infrastructure is defined as "*those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security*" (Attorney-General's Department 2010).

Physical infrastructures (PI) are public artefacts that are essential to sustain social and economic activities of a nation. Modern societies rely on the ability to move goods, people, and information safely and reliably. Infrastructures are vulnerable to increased temperatures, rainfall and flooding. Thus, even modest disruptions to infrastructure can have significant effects on daily life, and any systematic change in the frequency or intensity of those disruptions could have profound consequences for economic and human well-being.

Local governments make long-lived investments in physical infrastructure that are required to last for many decades. Thus infrastructure owned and managed by local government needs to adapt in order to reduce its vulnerability to and to cope with future climate change impacts.

Unpredictable extreme weather already presents a challenge to physical infrastructure. The impacts from the recent Queensland flooding and severe weather events emphasise the risks that infrastructure assets could face and the significant economic damage these types of events bring. In addition to the current threat, climate change is expected to pose further challenges for owners, operators and users of infrastructure. If current extreme weather events become both more frequent and extreme in the future, the level of disruption they cause will also

intensify. Consequently, it is of utmost importance to government, business, and the public at-large that the flow of services provided by a nation's infrastructure continues unimpeded in the face of a broad range of hazards (Little 2002). As infrastructure assets require a substantial capital investment and have long operational lifetimes they are sensitive not only to the existing climate at the time of their construction, but also to climate variations over their lifetime. Thus it is critical that infrastructure is designed, built, operated and maintained in a way that enables it to withstand current as well as future impacts of natural hazards, including climate change.

Enhancing adaptive capacity of new and existing infrastructure to climate change and natural hazards will not completely eliminate the risk of extreme weather events affecting infrastructure, nor the need for contingency plans to be in place. However, timely and proportionate adaptation actions across the PI sector can have a positive effect on the economic resilience of the country and, by increasing its climate resilience, contribute to creating a conducive environment for investment in infrastructure (Department of Environment, Food and Rural Affairs 2011a). Moreover, the cost of adaptation is small in relation to other factors that may influence the future costs of infrastructure. For example, a study undertaken by the World Bank (2010) estimates that the net cost of adapting infrastructure to climate change is no more than 1-2% of the total cost of providing that infrastructure.

10.3.2 Framework Rationale

Urban roads, local bridges and water networks are the largest items of expenditure for local governments in Australia (Jeff Roorda and Associates 2010). The investment in these long-lived assets means that local governments are exposed to considerable political, managerial and financial risks. Local government investments in physical infrastructure are long term and are required to last for many decades. Infrastructure asset management (design, operation and finance) has generally been based on past climatic conditions. However, given that climatic changes are expected over the next century, these historic conditions are no longer accurate indicators for planning, maintenance and upgrades. Hence, local government infrastructure needs to adapt to new climate risks to ensure appropriate infrastructure investment decisions are made to reduce long-term costs (Local Government Association of Queensland 2007). Additionally, there are many interdependencies between the different types of infrastructure and failure in one particular area can very quickly lead to cascading effects (Zimmerman & Restrepo 2009). These interdependencies need to be better understood to minimise and manage the impacts of climate change on infrastructure systems so they continue to be operational when extreme weather events occur.

An additional stressor to climate change threats to physical infrastructure is the fact that Australian local governments finance and management for infrastructure assets lack the financial requirements for the maintenance and rehabilitation of these assets (Australian Local Government Association 2011). This trend was confirmed by stakeholders involved in the special physical infrastructure workshop conducted by the Human Settlements team in the wake of the January 2011 floods in SEQ (see Low Choy et al 2012). Moreover, in the past, local authorities gave priority to the construction of new infrastructure ahead of maintenance and rehabilitation of existing

infrastructure. However, the increase in the frequency and intensity of extreme weather events as a consequence of climate change is likely to challenge such trend as costs associated with maintenance and rehabilitation of existing infrastructure may increase. For example, in the December 2010 and January 2011 floods, Queensland experienced one of the nation's most severe flooding: thirty-five people died in the floods; more than 78 per cent of the state was declared a disaster zone, with over 2.5 million people affected; and around 29,000 homes and businesses suffered some form of inundation (Queensland Floods Commission of Inquiry 2011). The estimated cost of flooding events alone is in excess of $5 billion. Although the floods caused widespread damage, some local government areas within SEQ were more affected than others. While there were minimal impacts in some local government areas, the severity of the impacts led others to apply for reconstruction funds from the state and federal governments. For instance, the extent of the flood damage caused to the physical infrastructure of the Lockyer Valley Regional Council locality (close to and with very similar attributes to the *Alphaville* human settlement type) is summarised below:

- Around 3,000 properties were inundated;
- Approximately 760 roads with a total length of 138 km (made up of 103 km sealed and 35 km gravel road) were flooded from both the flood itself and failure in the stormwater system;
- 14 bridges were damaged;
- 3 waste water treatment plants, 30 sewerage pump stations and 1 water river crossing were severely damaged; and
- Given the extent of the damage caused by the floods, the estimated medium to long-term recovery period for the local government area is 2 years.

It took five months for engineers to complete damage repairs and bring the town water and sewerage network back to normal, costing approximately $6 million. The immediate clean up alone incurred a cost of $8 million. Clearly, state and local governments, utilities, hospitals and emergency response organisations, and the community were largely under-prepared for an extreme event of this magnitude.

A study undertaken as part of the Local Adaptation Pathways Program (LAPP) funded by the Australian Government, which analysed findings of 94 local councils' efforts to plan for climate change adaptation, indicated that infrastructure is the second most important area of council's interest in-terms of risks (Climate Risk Pty Ltd 2011). In this study, risks to road and stormwater infrastructure were ranked first and third among the 10 most-cited physical infrastructure risks. Increasing the resilience of both new and existing roads and stormwater infrastructure systems is therefore a priority to ensure they remain operational in the face of a changing climate. The PI sector of the Human Settlements component of SEQ CARI focuses primarily on these two aspects of physical infrastructure: roads and stormwater systems in local government areas. Additionally, the adopted framework for physical infrastructure also recognises the need for strengthening the sector's adaptive capacity to deal with climate change (see Figure 8).

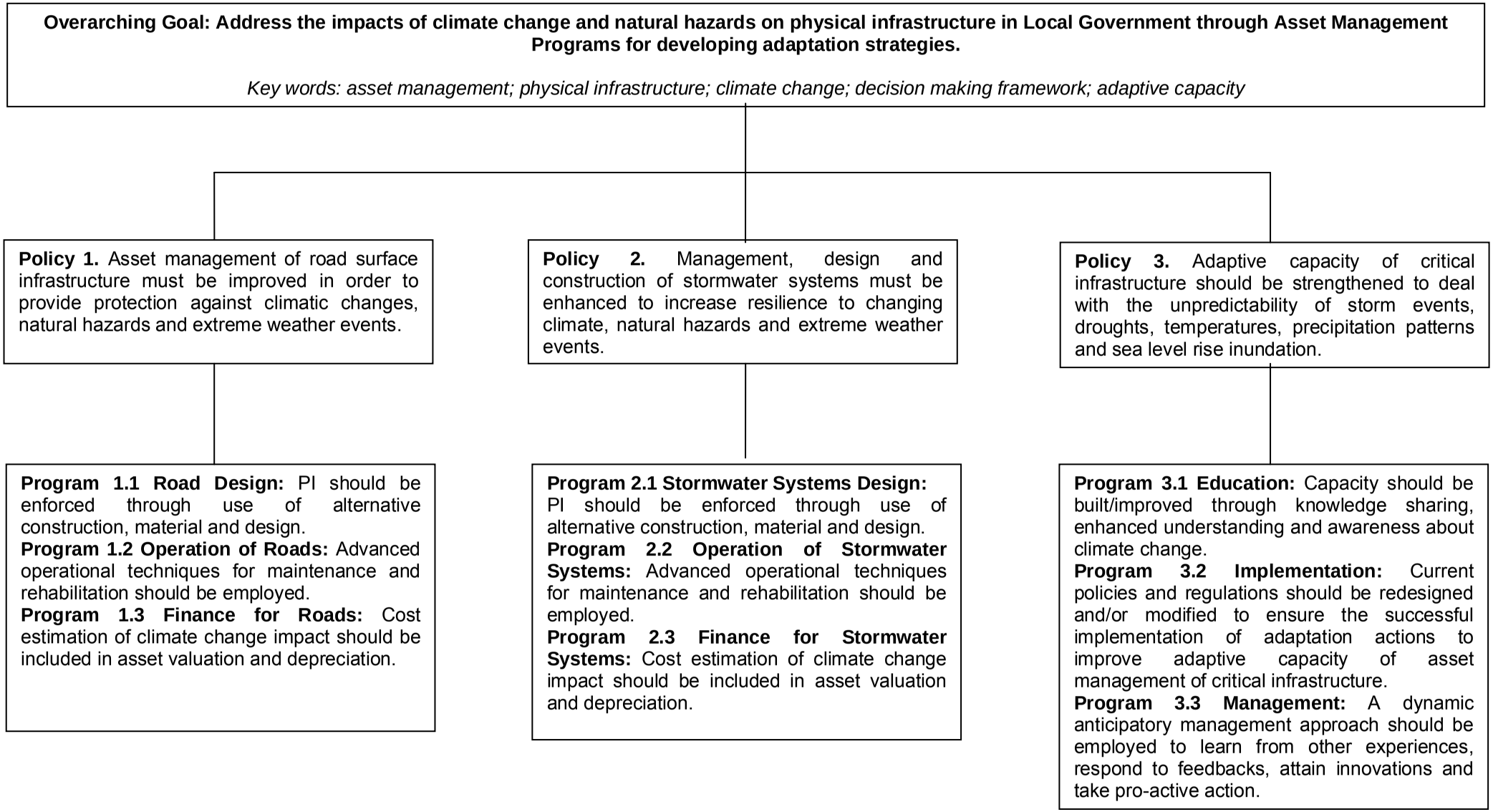


Figure 8: **Physical Infrastructure Adaptation Options Framework**

10.3.3 Formulation of Adaptation Options

The formulation of adaptation options is based on the findings of the literature review and outputs of workshops. These findings were then further substantiated by a series of interviews and consultation with key stakeholders within local governments and state agencies to increase sectoral understanding of the policy development and implementation process within government and non-government organisations. An additional (previously mentioned) special workshop was held on the need and opportunities for adaptation in two infrastructure areas: road and stormwater. Participants in this workshop were drawn from regulators and state and local government agencies.

The overarching goal for the adopted framework for the PI sector is to address the impacts of climate change and natural hazards on physical infrastructure in local government through Asset Management Programs for developing adaptation strategies (see Figure 8). Three important adaption policies are identified below:

Policy 1: Road: Asset management of road surface infrastructure must be improved in order to provide protection against climatic changes, natural hazards and extreme weather events.
Policy 2: Stormwater: Management design and construction of stormwater systems must be enhanced to increase resilience to changing climate, natural hazards and weather extreme events.
Policy 3: Adaptive Capacity: Adaptive capacity of critical infrastructure must be strengthened to deal with the variability of storm events, droughts, temperatures, precipitation patterns and sea level rise inundation.

The final structure of the adaptation framework was formulated based on the key messages received from stakeholder workshops, interviews and surveys. Adaptation actions identified earlier were then grouped under three program categories, namely: *Design*, *Operation*, and *Finance* for policies 1 and 2, and; *Education, Implementation* and *Management* for policy 3 (see Figure 8). Then a range of adaptation actions under these program categories were developed.

The above mentioned programs and their respective actions are also classified under the eight adaptation themes. These themes are based on key messages elicited by stakeholder feedback (Low Choy et al 2012), document analysis and literature review (see Table 9), and used across all Human Settlements sectors. Additionally the full physical infrastructure framework detailing policies, programs and actions in detail is provided in Appendix D3.

10.3.4 The implications of not adopting Adaptation Options

The primary purpose of the physical infrastructure adaptation framework, in the form of policies, programs and actions, is to provide guidance and options to assist policy and decision makers in their endeavours to prepare SEQ for natural hazards and future climate change impacts. While successful implementation of these adaptation options would improve the general community's adaptive capacity to manage the climate risk and seize opportunities, failure of implementation, however, may lead to significant economic, social and environmental losses with further consequences for both the region's liveability and sustainability.

Table 9: Distribution of PI programs across adaptation themes

Adaptation Theme	Program No.	Program
Preparing the Community		n/a
Support for Vulnerable Communities		n/a
Leadership, including Community Leadership		n/a
Proactive (Anticipatory) Initiatives	3.3	Management
Managing the (Urban) Environment	1.2 1.3 2.2 2.3 3.2	Operation of Roads Finance for Roads Operation of Stormwater Systems Finance for Stormwater Systems Implementation
Technological Development and Innovations	1.1 2.1	Road Design Stormwater Systems Design
Risk Communication		n/a
Training and Education	3.1	Education

Some of these consequences may include:

- Interruptions to essential services resulting from the destruction of, disruption of, or damage to, the physical infrastructure due to sea-level rise and/or natural hazards;
- Threats to road (transportation) infrastructure (through rapid deterioration, cut-off, closure etc.);
- Increased costs for local authorities and road authorities when repairing, maintaining and rehabilitating infrastructure because of flooding, land subsidence, and erosion;
- Health and safety hazards due to contaminations resulting from sewer, water treatment and water distribution networks flooding;
- Reduced life span of the infrastructure;
- Loss of production and services due to disruption in use of physical infrastructure facilities and services.; and
- Community anger, social unrest, injuries and fatalities due to delays and disruptions to road users.

10.3.5 Review of Research Questions

This physical infrastructure research has specifically focused on local government road and stormwater systems. The literature has clearly indicated that roads and stormwater infrastructures are among the largest items of expenditure for the local governments in Australia (Jeff Roorda and Associates 2010). Not surprisingly local governments rank road and stormwater infrastructure risks as the first and third among the 10 most important physical infrastructure risks (Climate Risk Pty Ltd 2011). It is clear that the investment in these long-lived assets could expose local governments to considerable political, managerial and financial risks.

Literature review findings are in line with, and complement, the outcomes of stakeholder workshops. Moreover, interviews and consultations with physical infrastructure asset managers within local governments in SEQ highlighted the importance of further research into the impacts of extreme weather events on roads and stormwater infrastructure.

Therefore the overarching goal of the physical infrastructure sector was set to address the impacts of climate change and natural hazards on physical infrastructure in local government through Asset Management Programs for developing adaptation strategies. In pursuit of this goal, physical infrastructure research questions for roads and stormwater were developed to inform local and regional asset management and adaptive capacity processes in SEQ. The specific physical infrastructure research question categories are:

1. *Pavement maintenance and deterioration*;
2. *Physical infrastructure management*; and,
3. *Stormwater systems and management*.

These research questions were addressed by developing appropriate policies, programs and associated actions set, within a physical infrastructure adaptation framework, as illustrated in Figure 8. Recognising the vital importance of stakeholder involvement in planning and implementing adaptation this research devised a mechanism to frequently engage stakeholders through workshops, interviews and consultations to formulate and explore the elements of this framework.

Stakeholders indicated that the collective effort of all sectors is the key to successful adaptation. They emphasised the importance of sectoral programs and policy integration. For example, stakeholders pointed out that in order to increase infrastructures resilience to climate change and natural hazards (including extreme events) at the planning and design stage, their interdependencies should be considered (e.g. construction of roads away from vulnerable stormwater networks). As a result, this suggestion was included as an action for both road (i.e. Action 1.1.6) and stormwater systems (i.e. Action 2.1.6) as shown in Appendix D3.

Research findings based on reviews of existing policies and programs in SEQ and stakeholder consultations indicate that local governments are aware that the changing climate may exacerbate the current natural hazard impacts, and therefore they have to act. As a result, climate change considerations are being incorporated into new planning schemes yet they are far from being sufficient due to restricted resources including funding, expert knowledge and a comprehensive framework dealing with design, operation and finance related issues of physical infrastructure. As observed during the 2011 floods, in many locations, the existing measures were not sufficient as they were not able to deal with the intensity of that event (Queensland Floods Commission of Inquiry 2012).

10.3.6 Recommendations for Future Research

Development of cross sectoral policies and frameworks should form part of future research and further development of the physical infrastructure adaptation framework. This will improve the understanding and coordination of adaptation

decision-making within and across sectors. Another research direction should evaluate techniques for applying the current physical infrastructure adaptation framework to other localities and at regional scales.

A final area for future research of potential adaptation options should be to establish procedures to rank them in terms of priority of implementation using appropriate techniques. A variety of tools and techniques are available for decision and policy makers to perform this task. In this latter regard, two techniques were trialled and are briefly reported on (see Appendix E). The two techniques were:

1. Multiple Criteria Decision Analysis (MCDA) – specifically the Analytic Hierarchy Process (AHP) – used here to test the evaluation and prioritisation of stormwater adaptation options. The MCDA was applied across the three coastal local government case studies and involving multiple local authority stakeholders (see Appendix E.1); and
2. Finite Element Method - used to evaluate the performance of both rigid and flexible pavements under different climate change scenarios (see Appendix E.2).

The purpose of these examples is twofold. In the first instance, they serve to evaluate adaptation options by using data obtained from key stakeholders in the local government case study areas and to provide recommendations. Secondly, they demonstrate effective usage of modelling simulations and decision-making tools. These two trials provide a 'proof of concept' and serve to show case appropriate prioritisation tools for stormwater and roads.

10.4 Emergency Management

10.4.1 Introduction

SEQ is a region already prone to natural hazards but is likely to experience an increase in the intensity and frequency of extreme weather events due to climate change. More frequent extreme weather events combined with the projected population growth and development in areas of high exposure, such as floodplains and along the coastline, will have significant implications for the emergency management sector. Emergency management agencies have been on society's frontline in dealing with disasters, but they will need to consider the new risks arising from climate change and how these will affect their ability to deal with and adapt to extreme weather events. Emergency management agencies will play a key role in reducing SEQ's human settlements vulnerability to extreme weather events and climate change.

10.4.2 Framework Rationale

In SEQ the disaster management system is based on the 'comprehensive', 'all hazards' and 'all agencies' approach. Disaster management should be planned across the four phases of prevention, preparedness, response and recovery, as directed by Queensland's *Disaster Management Act 2003* (DMA 2003). The framework adopted in this report for the development of adaptation options for the emergency management sector aligns with these four phases to maintain

consistency with the current approach to disaster management in SEQ. Although the appropriateness of this approach and the artificial separation of these four phases may be questioned, it was felt more useful to develop adaptation options within this existing approach rather than suggest a complete overhaul of the current system. Nevertheless, many of the policies and Programs put forward cut across the phases and these links are highlighted in Figure 9.

Adaptation options were developed for all four phases, as adapting to climate change in the emergency management sector will require significant improvements to all phases and elements of the disaster management approach (Yates & Bergin 2009). However, emergency management agencies alone will not be able to effectively reduce the vulnerability of SEQ's human settlements to extreme weather events. The National Strategy for Disaster Resilience recognises that a 'whole-of-government' approach will be required to adapt to climate change and in particular that the planning system will need to play a key role to reduce the vulnerability of settlements and contribute to safer and more sustainable communities (National Emergency Management Committee 2011). The emergency management adaptation framework, therefore, contains both sector-specific as well as cross-sectoral adaptation options, with a particular focus on more effective integration with the planning sector.

Overarching Goal: To increase the resilience of SEQ's emergency management sector in a changing climate.

Key words: emergency management, climate change, community preparedness, long term disaster recovery, capacity building, community leadership

Prevention

Policy 1. State and local governments integrate long term post-disaster recovery considerations into pre-disaster planning processes.

Program 1.1 Long term post-disaster recovery plan: State and local governments develop a long term post-disaster recovery plan. This plan should identify policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of a community after a disaster.

Program 1.2 Post-disaster recovery in pre-disaster plans: Long term post-disaster recovery considerations are integrated into pre-disaster plans of government agencies leading recovery processes.

Program 1.3 Community engagement: Communities are engaged in the development of the long-term post-disaster recovery plans.

Policy 2. A series of programs to integrate emergency management and urban planning and management processes to more effectively reduce vulnerability of communities to climate change.

Program 2.1 Emergency management integrated into land use planning and development: Emergency management considerations are integrated into urban planning decisions related to land use planning and development.

Program 2.2 Emergency management integrated into state planning policies: The integration of emergency management into state planning policies is improved.

Program 2.3 Strategic relocation and upgrade of essential emergency services: Emergency services and facilities (e.g. disaster management warehouses, disaster coordination centres, evacuation centres) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks to ensure these services and facilities can continue to operate during emergencies. This should include considering threats to infrastructure, such as communications and roads.

Program 2.4 Capacity building and training program: A capacity building and training program on emergency management, climate change and urban and regional planning is developed and implemented.

Preparedness

Policy 3. A series of programs will be introduced to improve the level of preparedness of communities to climate change and new climatic risks.

Program 3.1 Preparedness of vulnerable communities: The preparedness of vulnerable communities to current and future climatic risks is improved.

Program 3.2 Preparedness of private and community sectors: The preparedness of private and community sectors to climate change and new climatic risks is improved.

Program 3.3 Real estate sector and hazard awareness: The real estate sector is engaged to improve hazard awareness amongst property owners.

Program 3.4 Community education and awareness raising campaigns for vulnerable groups: Community education and awareness raising campaigns/initiatives targeted at vulnerable groups, including new residents and seasonal visitors, are developed and implemented. These campaigns will focus on natural hazard preparedness, response (including evacuation) and recovery, and potential climate change implications for the area and communities targeted to promote greater ownership of hazard risks and more self-reliant and empowered individuals and communities.

Program 3.5 Bushfire Community Training Package: Continue to implement Queensland's Bushfire Community Training Package.

Response

Policy 4. An integrated group of programs to support and enhance the emergency management capacity and capability of local governments in light of the changing risk profile due to climate change.

Program 4.1 Redundancy and back up for essential emergency management services and facilities: High priority emergency management services and facilities, such as Local Disaster Coordination Centres, evacuation centres, hospitals and alternative access routes are decentralised and/or equipped with back-up systems.

Program 4.2 Local government emergency management capacity: The emergency management capacity of local governments is improved.

Program 4.3 Communication between local councils: Improved and increased communication between emergency management personnel across local councils is facilitated.

Program 4.4 'Support our Heroes': Continue to implement Queensland's Support our Heroes Program to strengthen the response capacity of SES and Rural Fire Service.

Policy 5. Stronger regional collaboration between local governments for emergency events is facilitated through a buddy system sponsored by the Council of Mayors (SEQ).

Program 5.1 Mutually supportive councils: Councils establish and maintain agreements with each other to provide assistance if required during an emergency event.

Recovery

Policy 6. A series of programs facilitated by emergency management agencies to more effectively support the role of communities in disaster response and recovery to promote greater community resilience to extreme weather events and climate change.

Program 6.1 Community training programs: Community training programs in response and recovery are developed for community groups.

Program 6.2 Community Leadership: Community leadership during and after disasters is supported to promote improved disaster response and recovery.

Figure 9: Emergency Management Adaptation Options Framework

10.4.3 Formulation of Adaptation Options

A brief overview of the adaptation options formulated around the four phases of disaster management is provided. While the options are presented separately under each phase several options cut across one or more phases, as mentioned previously.

Prevention phase

The prevention phase consists of initiatives that seek to "reduce the likelihood of an event occurring or, if an event occurs, to reduce the severity of the event" (State Disaster Management Group 2011: 4). Prevention activities can include structural measures, such as levees and dams, as well as non-structural measures, such as building codes, zoning and land use planning regulations, and relocation measures. The planning sector has a critical role to play in reducing communities' exposure to extreme weather events and thus facilitate adaptation to climate change. The two policies for the prevention phase proposed in this Emergency Management Adaptation Framework are structured around this recognition of the critical role of planning in disaster management.

Policy 1 in the Emergency Management Framework aims to link the recovery and prevention phases, as it is argued that post-disaster recovery can play a key role in increasing the resilience of affected communities and should be seen as a first step in the prevention of future disasters. Further, while urban planning has traditionally played a role within the prevention phase of disaster management, there is an increasing belief that urban planning should also play a key role in disaster recovery (Siembieda et al 2004; Blanco et al 2009; Meyer et al 2010). Therefore, Policy 1 recommends that long-term disaster recovery considerations be integrated into pre-disaster planning processes. This is based on work by Meyer et al (2010) and the Florida Division of Emergency Management in the United States. Policy 1 has relevance for both the prevention and recovery phases. It is a cross-sectoral policy that will require the involvement of all sectors and actors involved in the recovery process at local, regional and state levels, with key roles for the planning and emergency management sectors. Such a post-disaster recovery plan developed in a pre-disaster phase would provide the broad avenues for redevelopment and reconstruction following a disaster. Current disaster recovery planning is mostly reactive so this approach would enable a more proactive process of disaster management and planning. As stated by Meyer et al (2010: 552) 'without a clearly defined strategy for long term recovery before the disaster, communities become victims to their circumstances'.

The second policy proposed in the framework is built around the recognition that a stronger emphasis on land use planning as a mitigation tool and a greater involvement of disaster managers in the planning process are critical to the prevention of disasters and to climate change adaptation (Boullé et al 1997; Pearce, 2003; Siembieda et al 2004; Norman 2009; Yates and Bergin 2009; Buxton et al 2011). Although this need for improved integration has been recognised for many years, very little progress has effectively been made. Despite the SEQ Regional Plan claiming that "the planning process in SEQ can reduce the risks from natural hazards and the projected effects of climate change" (Department of Infrastructure and Planning 2009: 44), it is evident from the January 2011 floods that the current

planning process and planning tools have failed to sufficiently mitigate the risks from natural hazards, and in particular flooding. The State Planning Policy (SPP) 1/03 does not incorporate climate change considerations and only recommends the use of one flood level, the Q100 level, for managing flood risk for urban settlements. There is also very little evidence of the integration of emergency management considerations within this state planning policy. The 2010 Inland Flood Study undertaken by the Queensland Government provided recommendations for the review of SPP 1/03 including the need for it to "consider how to improve the integration of land use planning and disaster management planning" (Office of Climate Change et al 2010: 3). This need to establish links between emergency management, climate change and land use planning to reduce communities' exposure to risks from natural hazards was also emphasised in the Commonwealth Department of Climate Change and Energy Efficiency's 2009 report on climate change risks to Australia's coast (Department of Climate Change 2009).

Preparedness phase

Climate change is expected to result in an increase in the frequency and intensity of extreme rainfall events and in more frequent inundation from storm surges due to the combination of more intense weather events and high sea levels. These changes will require improved preparedness from communities, private and community sector organisations and emergency management agencies. Greater emphasis on household and community preparedness will be required, as current levels of household and community preparedness in Queensland and throughout Australia are considered low (Dyer et al 2001; Gissing et al 2010). Policy 3 focuses on improving the levels of preparedness of communities and private and community sector organisations to climate change through a series of Programs to build capacity and raise awareness. In addition, some of the Programs and actions are deliberately targeted at specific groups identified as having particular vulnerabilities and/or needs. This policy also contains a Program specifically targeted at the real estate sector, as it is argued that this sector needs to play a greater role in improving hazard awareness among property owners, including intended owners.

Policy 4 focuses on enhancing the emergency management capacity and capability of local governments, as interviews with state and local government stakeholders revealed limits to local government response capacity and the sector's need for greater resources. In addition, emergency managers stated they did not have sufficient access to information on climate change and its impact on their sector and expressed their desire for greater collaboration and sharing of information and experience between local governments. Policy 4 is a cross-cutting policy also relevant to the response and recovery phases.

Response and Recovery phases

The final set of policies cut across both response and recovery phases. Climate change will create additional pressures on the emergency response services and will also require a greater focus on recovery.

Emergency services will need to assess how climate change will affect the continuity and supply of their services, especially if multiple events occur at the same time. In Queensland, and throughout all Australian jurisdictions, the response to and recovery from a disaster relies heavily on volunteer organisations, including the State

Emergency Services (SES). Climate change is expected to increase the demand on the services of the SES across the whole spectrum of their responsibilities at a time when the SES are already experiencing a greater demand for their services (Howard 2009; Yates and Bergin 2009; Gissing et al 2010). A recent review of Australian case studies on the management of extreme weather events also found that although the response of the emergency services was effective they were at times working very close to full capacity suggesting that a small increase in event severity or duration would compromise their ability to respond effectively (Kiem et al 2010). Policy 4 addresses this issue by supporting the strengthening of the response capacity of the SES, Rural Fire Brigade and other volunteer organisations.

Policies 5 and 6 were developed in response to the findings emanating from the stakeholder interviews. These interviews revealed that whilst local governments needed and were willing to collaborate during the response and recovery phases they faced potential institutional/regulatory barriers preventing them from collaborating. Policy 5, therefore, recommends developing a regional collaboration system between local governments. This Policy is supported by actions to identify the most appropriate collaboration process and to integrate this into the current State disaster management arrangements. Finally, Policy 6 supports promoting the role of communities in disaster response and recovery to achieve greater community resilience. The emergency management sector in Queensland is approaching climate change adaptation through a resilience perspective and is thus promoting greater community responsibility. The interviews with local government stakeholders revealed that some local governments are already trying to work more closely with community groups for improved disaster risk management by the community. Policy 6 supports this approach but also recommends going one step further by promoting community leadership during the response and recovery phases. Despite the resilience and community responsibility approach adopted by the emergency management sector, there is still reluctance among emergency managers to give community groups response and recovery powers that would be recognised in the state disaster management arrangements. This option needs to be further investigated, as identified in the actions supporting this policy.

A series of discrete actions were generated for each of the programs under the six policies to provide further details on implementation, monitoring and performance evaluation (see Appendix D4 and the accompanying Supplementary Report). The programs and their respective actions are classified in Table 10 which is based on an enhancement of the eight adaptation themes identified by Low Choy et al (2012), the analysis of stakeholder workshop outputs and stakeholder feedback obtained throughout the course of this project.

10.4.4 Implications of not adopting Adaptation Options

The first SEQ CARI report revealed some of the key challenges for the emergency management sector in the face of climate risks (see McDonald et al 2010). These challenges included: integrating climate change into disaster management plans; improving disaster management arrangements, including the coordination of and collaboration between the different agencies involved in emergency management in SEQ; Queensland's reliance on a high level of volunteer support; and the need to

Table 10: Distribution of EM programs across adaptation themes

Adaptation Theme	Program No.	Program
Preparing the Community	3.2 3.3 3.5 4.4 6.1	Preparedness of Private and Community Sectors Real Estate Sector and Hazard Awareness Bushfire Community Training Package Support our Heroes Community Training Programs
Support for Vulnerable Communities	3.1 3.4	Preparedness of Vulnerable Communities Community Education and Awareness Raising Campaigns for Vulnerable Groups
Leadership, including Community Leadership	6.2	Community Leadership
Proactive (Anticipatory) Initiatives	1.1 1.2 1.3	Long Term Post-Disaster Recovery Plan Post-disaster Recovery in Pre-Disaster Plans Community Engagement
Managing the (Urban) Environment	2.1 2.2 2.3 4.1	Emergency Management Integrated into Land Use Planning and Development Emergency Management Integrated into State Planning Policies Strategic Relocation and Upgrade of Essential Emergency Services Redundancy and Back up for Essential Emergency Management Services and Facilities
Technological Development and Innovation		n/a
Risk Communication		n/a
Capacity building, Training and Education	2.4 4.2 4.3 5.1	Capacity Building and Training Program Local Government Emergency Management Capacity Communication Between Local Councils Assistance Between Councils

better understand the implications of climate change for the sector. The adaptation options described in the above section and provided in Appendix D4 will help address these challenges, as they aim to improve the effectiveness of all four phases of disaster management in the face of the pressures that will arise from climate change. The failure of adopting these adaptation options will lead to increasing pressures on over-stretched, under-resourced and under-prepared emergency management agencies, a lack of preparedness of communities and an inappropriate short-term approach to recovery. In addition, a failure to improve the integration between the emergency management and planning sectors and the consideration of emergency management needs in urban planning processes will likely result in the development of settlements in high risk areas which will lead to a greater exposure to extreme weather events, as well as a greater strain on emergency management services who will be required to intervene more frequently. Many of the recommended adaptation options also represent 'no-regrets' options, as their implementation would contribute to improvements in the four phases of disaster management regardless of climate change impacts. For instance, improving communities' preparedness will have benefits even under current climatic conditions, as many communities are inadequately prepared for extreme weather events. Recent extreme weather events in Queensland have also highlighted the need to

provide further support to emergency services and in particular to local governments who have primary responsibility for emergency management but yet have insufficient financial and human resources and sometimes lack experience in emergency management. For example, for some of the smaller councils, the SEQ January 2011 floods, was the first time they had been activated for disaster management. Hence, many of the adaptation options developed are aimed at improving local government's capacity to respond to extreme weather events.

10.4.5 Review of Research Questions

This research investigated the following five key issues in the context of emergency management in SEQ: i) the sector's capacity to work across the PPRR spectrum in the face of climate change; ii) current adaptation initiatives within the sector; iii) institutional and policy arrangements for emergency management; iv) supporting and enhancing communities' ability to deal with climate change; and v) cross-sectoral integration to improve the management of disasters, in particular the prevention and recovery phases. The adaptation options developed in the Emergency Management Framework address those research questions, as they focus on all four phases of disaster management, build on current adaptation initiatives, address some aspects of the institutional arrangements in particular between local governments and across sectors, emphasise community preparedness as well as communities' role in disaster management and highlight the need for improved cross-sectoral integration, particularly between the emergency management and urban planning sectors.

10.4.6 Recommendations for Future Research

In Australia's first National Climate Change Adaptation Research Plan on Emergency Management and Climate Change, the authors recognised that adaptation research in the field of emergency management was still at an embryonic stage (Pearce et al 2009). The research presented in this report contributes to this emerging field but recognises that many gaps still exist. In particular, an emerging research agenda for the emergency management sector is the issue of responsibility and especially shared responsibility between communities and government agencies. Emergency management agencies in Queensland are approaching climate change adaptation under the resilience 'banner' and are increasingly emphasising the need for communities to take greater responsibility, yet there has been little discussion regarding what this actually means and how this plays out on the ground. In addition, further research is needed on the recovery phase of disaster management and in particular the long-term and strategic aspects of recovery. The recovery phase has often been neglected by emergency management agencies yet this phase is vital to breaking the disaster cycle and will therefore have a key role to play in building resilience and adapting to climate change. The integration of long-term recovery into pre-disaster planning processes also requires further investigation in the Australian context. Finally, further research is required to investigate the role of planning in not only preventing but also recovering from disasters and how planning can better integrate emergency management considerations for effective climate change adaptation.

10.5 Human Health

10.5.1 Introduction

Changes in climate such as increased frequency of floods, heat wave, storms, and drought are expected to have implications for the health sector in SEQ, and will vary spatially and across different social groups. Vulnerabilities and attributes of resilience to climate change health impacts may be related to a range of features of urban systems such as socio-economic characteristics, built form, structure and density, access to resources, and social networks (Low Choy et al 2010). The extent of health impacts of climate change will also depend to a large degree on arrangements for climate adaptation and the adaptive capacity of health institutions as well as communities and the private sector.

Document analysis has revealed that currently the health sector in SEQ does not have any specific programs or strategies explicitly related to climate change adaptation (confirmed by interview with state government respondent). However, it must be noted that over the past few years much work has been done in the health sector to increase adaptive capacity more broadly, which has increased the sector's resilience to climate change impacts (state government interview respondent).

Regulatory powers of the health sector are mainly directed towards ensuring that there are adequate standards of health services, and public protection from unacceptable health hazards. Considering the wide breadth of environmental, social and economic determinants of health in urban environments, the health sector arguably has little regulatory powers. However, health institutions may be considered influential and persuasive in public policy arenas. Many health organisations have been increasingly engaging with other sectors and initiatives to collaborate and develop synergistic initiatives that simultaneously help to mobilise policy goals across sectors.

"*Much of public health is in the hands of other agencies …. we have our influence, which from a health department is quite powerful. You know, if the health department says something is dangerous, that's quite influential over the community. So we don't have a lot of law but we have a lot of influence and the law is largely in the hands of the urban planning agencies, particularly when it comes to climate change"* (state government interview respondent).

10.5.2 Framework Rationale

Frumkin et al's (2008) categorisation of challenges of climate change and adaptation options for human health (as shown in Table 11) was used as an overarching starting point for the development of the adaptation options framework. Table 11 illustrates the correspondence between Frumkin et al's nine public health roles and the four policies constituting the human health adaptation options framework.

Table 11: Climate change challenges for public health

Public Health Role	Climate Change Example	Corresponding Human Health Policy
1. Monitor health status to identify and solve community problems	Tracking of diseases and trends related to climate change	Policy 4
2. Diagnose and investigate health problems and health hazards in the community	Investigation of infectious water-food and vector borne disease outbreaks	Policy 4
3. Inform, educate and empower people about health issues	Informing the public about health impacts of climate change	Policy 2
4. Develop policies and plans that support individual and community health effects	Municipal heat wave preparedness plans	Policy 1
5. Mobilise community partnerships and action to identify and solve health problems	Develop public health partnerships and recognise cross-sectoral limitations	Policy 2
6. Link people to needed personal health services and ensure the provision of health care when otherwise unavailable	Health care service provision following disasters	Policies 2 & 3
7. Ensure competent public and personal health care workforce	Training health care workers about new and emerging issues associated with climate change	Policy 2
8. Evaluate effectiveness, accessibility and quality of personal and population-based health services	Program assessment of plans	All Policies
9. Research for new insights and innovative solutions to health problems	Undertake research into climate change and health impacts	Policy 4

Source: adapted from Frumkin et al 2008

The Human Settlements overarching framework for human health organises adaptation options into four policies described below:

Policy 1: focuses on the capacity of primary health facilities to respond to emergency/short term climate change impacts such as increase in the severity or frequency of extreme weather events and consequent surges in demand for primary health services. Heat wave management is included in this policy in recognition of the potential for heat events to result in significant surges in demand for health services in the absence of adequate adaptation measures.

Policy 2: presents adaptation options focused on capacity building across not just government health departments and services, but also integrates actions at a community level, and utilises social networks and environmental/urban planning. This policy includes measures relating to training, and increasing awareness of health impacts of climate change across a range of actors.

Policy 3: in recognition of the broad range of determinants of health for different communities and populations, Policy 3 attempts to integrate and elicit links between human health adaptation options and adaptation options of other sectors in the

Human Settlements component – emergency management, physical infrastructure and urban planning and management.

Policy 4: focuses on surveillance and monitoring of impacts of climate change at a population health level, allowing health services to track, anticipate and respond to changes in disease patterns. This includes integrated monitoring of social determinants of health, environmental indicators, and epidemiological monitoring and response. Policy 4 also encourages further research and development for climate adaptation for human health.

The full adaptation options framework containing the four human health policies and associated programs is illustrated in Figure 10. It also illustrates the correspondence between the four human health policies and the nine public health roles of Frumkin et al (2008).

Overarching Goal: To establish adaptation strategies to minimise vulnerability of SEQ residents to adverse human health impacts associated with climate change.

Key words: human health, adaptive capacity, risk communication, preparedness, heat wave, mental health, community resilience, volunteers, surveillance & monitoring

KEY: Public health role (see Table 11)

Policy 1. Responses to human health impacts of extreme weather events and projected changes in climate should be enhanced through strengthened and expanded health initiatives and emergency preparedness.

4. Develop

8. Evaluate

Program 1.1 Service Continuity in Disaster: Emergency Preparedness and Continuity Management assists health facilities to cope with changing risk profiles as a result of climate change.

Program 1.2 Heat wave management: Heat wave management and response is improved to minimise health risks during hot weather events.

Program 1.3 Psychosocial Support: Mental health and psychosocial support is enhanced through working with vulnerable communities.

Policy 2. Health risk minimisation and capacity building for communities, private sector and government departments should be assisted through a range of initiatives and programs.

3. Inform etc

5. Mobilise

6. Link

7. Ensure

8. Evaluate

Program 2.1 Community capacity-building: Capacity to adapt to health impacts is enhanced through identifying and supporting social networks.

Program 2.2 Community risk awareness: Health risk management is facilitated through communication and community awareness initiatives.

Program 2.3 Supporting Volunteers: Volunteer retention and volunteer capacity to respond to health impacts and risks associated with climate change is improved through volunteer management and training.

Program 2.4 Improved availability of information: Improved availability of information for health authorities, professionals, private sector and other decision-makers assists their capacity to adapt to climate change-related health hazards.

Program 2.5 Leadership development through collaboration: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Policy 3. Integration of health initiatives with policies and plans in other sectors to enhance climate adaptation efforts for human health.

6. Link

8. Evaluate

Program 3.1 Integration with Emergency Management: More integrated actions with emergency management assists the delivery of health services for frontline emergency health personnel and vulnerable groups that are susceptible to climate change health impacts.

Program 3.2 Integration with Urban Planning and Management: Integration of human health into urban planning and management increases resilience and reduces susceptibility to adverse health impacts of climate change.

Program 3.3 Integration with Physical Infrastructure: The vulnerability of communities and health services to climate change is minimised by further integrating human health considerations in the planning and management of physical infrastructure.

Policy 4. Surveillance and monitoring for human health should be strengthened in order to have timely responses to future climate impacts.

1. Monitor

2. Diagnose

8. Evaluate

9. Research

Program 4.1 Improved understanding: Research, surveillance and monitoring leads to improved understanding of relationships between population health and climate change and capacity to respond to future health risks.

Program 4.2 Risk management and population health: Surveillance and monitoring allows for continuous improvement in risk management at a population health level.

Figure 10: Human Health Adaptation Options Framework

10.5.3 Formulation of Adaptation Options

Adaptation options were generated from the literature review, document analysis and informed by stakeholder feedback through several series of multi-sector stakeholder workshops and stakeholder interviews.

Stakeholder interviews represented a wide range of organisations involved in climate adaptation for human health in SEQ. This included personnel from NGOs, local government (including staff working on issues of environmental health and community health) and state government. Participants at workshops represented a wide array of organisations working with issues of human health – through Public Health Units and NGOs. This broad stakeholder representation was based on recognition of the important role of industry, communities and social networks as well as formal organisations and government and non-government institutions in human health protection and promotion. Adaptation options to improve public health systems were rated high by stakeholders (including PRG members) in workshops. There was also stakeholder recognition of wider environmental and social determinants of health, which is reflected in the adaptation options subsequently generated.

Table 12 illustrates the distribution of the human health programs under the general adaptation themes identified in stakeholder feedback (Low Choy et al 2012), document analysis and literature review. It must be noted that many proposed human health programs can relate to more than one of these themes and it is the dominant alignment that has been tabulated. For instance, Program 1.3 (Psychosocial Support) includes actions relating to training and education; and Program 2.1 (Community Capacity Building) includes initiatives that foster community leadership.

Table 12: Distribution of HH programs across adaptation themes

Adaptation Theme	Program No	Programs
Preparing the Community	2.1 3.1	Community Capacity Building Integration with Emergency Management
Support for Vulnerable Communities	1.3	Psychosocial Support
Leadership, including Community Leadership	2.5	Leadership Development through Collaboration
Proactive (anticipatory) initiatives	1.1 1.2 4.1	Service Continuity in Disaster Heat wave Management Improved Understanding
Managing the (Urban) Environment	3.2 3.3	Integration with Urban Planning and Management Integration with Physical Infrastructure
Technological Development and Innovation		n/a
Risk Communication	2.2 2.4 4.2	Community Risk Awareness Improved Availability of Information Risk Management and Population Health
Training and Education	2.3	Supporting Volunteers

10.5.4 Implications of not adopting Adaptation Options

Health impacts cannot be directly correlated with the simple metrics of climate change, such as changes in average temperature or rainfall deciles. This is especially true of indirect health impacts of climate change such as mental health impacts stemming from population dislocation and changes to local economies. However, limited data to support predicted health impacts of climate change should not be interpreted as meaning that these health impacts will not be significant. Steps to protect the public from health threats of climate change cannot await complete scientific certainty and the notion of using 'margins of safety' to protect public health is consistent with prevailing health practice (Frumkin et al 2008).

Failure to adopt adaptation options may translate into lost opportunities to minimise injuries and fatalities related to extreme weather events, infectious diseases related to changes in vector biology water and food contamination; respiratory and cardiovascular disease related to worsening air pollution and increased heat; and nutritional impacts of changes in food production patterns (Frumkin et al 2008). More specifically, failure to adopt the proposed adaptation options advanced may lead to:

- continued lack of understanding of the future potential extent of health burdens associated with climate change in SEQ (McDonald et al 2010);
- missed opportunities for disease prevention (McDonald et al 2010);
- failure of population health surveillance and monitoring systems to manage increases in infectious disease stemming from changes in climate (McDonald et al 2010);
- missed opportunities for integrated and interagency measures to help reduce health impacts on vulnerable populations through cross-sector climate adaptation (McDonald et al 2010);
- exacerbated health impacts (including mental health impacts) associated with extreme weather events through failure to build community resilience or foster community action for health prevention and protection (NGO interview respondent); and
- failure to include a strong role for communities and support for health initiatives at a community level. This could mean that other initiatives are constrained or less cost effective (see Low Choy et al 2012).

10.5.5 Review of Research Questions

Despite there being no explicit climate change adaptation strategies in the health sector in SEQ, it must be acknowledged that work is being done to increase adaptive capacity of the sector to anticipate and proactively respond to extreme weather events and climate variability. This includes work to expand environmental monitoring for dengue fever management, review of Incident Management Systems, use of seasonal forecasts to inform emergency health preparation, post-disaster health surveys, and efforts to increase cross-sectoral collaboration. These measures have been taken into consideration when addressing the research questions and developing adaptation options.

Stakeholder feedback indicates a need for collaborative approaches that integrate both community-based initiatives and land use planning into public health planning in order to achieve health goals relating to climate change adaptation. This indicates the importance of questions regarding how best to simultaneously engage

community-based groups, land use planners, and public health officials to implement health protection measures that are co-beneficial for health organisations as well as other sectors. Research findings also raise questions regarding how best to resource community-level action so social networks may play a strong and sustained role in managing health risks associated with extreme weather events and climate variability. It also raises additional questions regarding how to best include community-based initiatives in formal health and disaster management institutions whilst maintaining adequate community ownership.

The following section summaries the adaptation option responses to the original human health research questions drawing from literature review, document analysis and stakeholder feedback in all previously discussed forms.

- ***Potential climate change impacts on health sector – locally and regionally***
    a. *What types of climate change impacts may influence the health and wellbeing of local communities within the local area and the larger SEQ region?*
    b. *Identify the range of these impacts spatially, temporally and with regards to their potential frequency, intensity and nature of impact*

Literature and stakeholder feedback suggest that the most significant health impacts of climate change will stem from: an increased morbidity and lost productivity resulting from heat waves; increased loss of life, injury and mental health impacts stemming from flooding and storms; and challenges to the health system, livelihoods and wellbeing as a result of drought and water scarcity (state and local government interview respondents; NGO interview respondent; McMichael 2003; Baum et al 2009; Low Choy et al 2010). These impacts are not expected to be evenly distributed spatially or socially.

An increase in Brisbane's average temperature by 1.64°C over 1990 levels could increase heat-related deaths from an average of 134 to over 1000 deaths per year by 2050 (McMichael et al 2003). An increase in Brisbane's average temperature of 3 to 4°C is predicted to result in increased heat-related health risks and an increase in Brisbane's peak electricity demand of 5 to 20% (Preston & Jones 2006). This may occur as soon as 2070 (Walsh et al 2002), causing spikes in peak energy demand that can exceed the available capacity of electricity generating systems, leading to load shedding, which in turn exacerbates the impact of a heatwave on urban health (Granger & Brerechree 2000). In such a situation, vulnerable people who are dependent on their own private air-conditioning become exposed to heat-related health risks.

It appears that expanded impervious surfaces have led to increased temperatures in SEQ's urban coastal areas of the Gold Coast and Sunshine Coast, and the bayside areas of Brisbane City and Moreton Bay Regional Council. Isolated localities in SEQ's western corridor and Logan City may also experience relatively high heat exposure compared to the region which may be compounded in population pockets with lower socio economic status characterised by lower adaptive capacity (Low Choy et al 2010).

Recent flooding in SEQ brought a swathe of health impacts, illustrating some of the challenges of increased rainfall variability expected to accompany climate change. Many of these challenges related to disrupted infrastructure and delivery of health

services, health protection during disaster recovery, and surges in demand for psychosocial support services (which may last longer after a flood event) (Green 2011; Queensland Alliance for Mental Health 2011).

In interviews, local government and state government respondents have also pointed to health implications of reduced average rainfall and increased frequency of drought for SEQ. Not only are critical health facilities large consumers of water, but water demand management measures may have implications for environmental health and livelihoods (thus influencing social determinants of health) (The Climate Institute 2011).

- ***Role of health institutions***
    a. *How can local and regional health and lifestyle institutions – government, community-based and/or private – strengthen adaptive capacity of communities to address potential climate change impacts on health?*

> '*I'd like to see us taking an authentic community building approach'* (state government interview respondent).

Some social groups and geographical areas are more vulnerable to climate change health impacts than others. Literature and stakeholders have suggested the development of initiatives that are tailored to the particular characteristics of vulnerable communities and/or neighbourhoods, and that allow for community ownership - tapping into existing community leaders, social networks and their resources (Wilhelmi & Hayden 2010; NGO interview respondent; Strand et al 2010; Henderson & Kendall 2011). This may require community-driven approaches, allowing community groups to stipulate which initiatives are most needed in their local areas and how they are implemented:

> "*It can't be community driven if you're not giving them an opportunity to actually say, 'I need this', or 'I could help do this', or to actually tell you where the vulnerability is. So it has to be community driven. But we're not good at that. We're normally good at charging in on our white horses and saying, 'You need this'* " (NGO interview respondent).

Literature and local experience suggests that partnerships between formal health services and community-based social networks may facilitate appropriate care that is specific to the particular needs of vulnerable communities and can promote greater uptake of health prevention strategies (Laverack 2006; Henderson & Kendall 2011; Eng & Parker in Henderson and Kendall 2011). Feedback from multi-sector stakeholder workshops also suggests a belief that partnering with community leaders and organisations may bring a high likelihood of cost effectiveness whilst promoting resilience (Low Choy et al 2012). However, some stakeholders expressed caution from making assumptions and expectations of sustained commitment at a community level for all aspects of climate adaptation. It was also pointed out that community organisations require adequate resourcing if they are to acquire roles in climate adaptation for human health (NGO interview respondent). This is also indicated in literature (Disability Disaster Advocacy Group 2009; Abrahamson & Raine 2009).

- ***Health planning evaluation***
    a. *How effective are existing health-oriented planning measures for climate change adaptation that consider social and locational disadvantage?*

Certain social groups, such as culturally and linguistically diverse communities in Australia are known to often experience limited access to health care services, resulting in poor health outcomes (Henderson & Kendall 2011). Additionally, disadvantaged communities tend to bear the greatest burden of ill health (QCOSS 2011). These health inequities may compound adverse health impacts of climate change for disadvantaged and marginalised populations, and lower socioeconomic status neighbourhoods, and socially isolated individuals (Edwards & Wiseman 2010). Social isolation, socioeconomic status and neighbourhood characteristics, and pre-existing health of individuals may greatly influence their vulnerability and susceptibility to adverse health impacts of climate change and extreme weather events. As such, these aspects need to be included in disaster management and health planning for climate adaptation.

QCOSS (2011) has called for flexible service models and funding for Medicare Locals to strengthen the primary health care response for disadvantaged and marginalised groups and for integrated planning and flexible service models for disadvantaged and marginalised groups. Considering that economic marginalisation and low socioeconomic status are contributors to vulnerability to health impacts of climate change, these measures may contribute to reducing health risks associated with climate change. Climate adaptation strategies aimed at community-level risk management can be overlaid with policies to reduce social inequalities and improve the social and environmental conditions that influence health behaviours, health outcomes and urban management relating to climate adaptation (Edwards & Wiseman 2010). This requires integration of planning for health equity and multiple aspects of urban management, as health care is one of many determinants of health and equity (Keleher 2011).

Within SEQ, some suburbs have been identified as being disadvantaged in terms of transport options (Johnson & Herath 2004). Local government and transport authorities may have a role to play in increasing health equity through maximising transport options and accessibility of health services. In terms of managing health impacts of heat waves, maximising transport options and accessibility of public air-conditioned spaces may reduce health risks for areas identified as having lower socioeconomic status, higher transport disadvantage, and higher vulnerability to extreme heat and managing heat-related health risks through maximising transport options and accessibility of health services and public air-conditioned spaces (Blum et al 1998).

- ***Barriers in health adaptation***
    a. *Identify existing barriers to inter-agency coordination in responding to natural hazards and/or potential sudden and slow on-set climate change impacts.*
    b. *What measures need to be developed to facilitate timely and effective integration of response efforts both within and across agencies (vertically and horizontally).*

Lack of information sharing across departments and organisations, workplace culture, lack of funding for policy development that is inclusive of communities and scientific research, use of different language and jargon across different sectors, and time constraints may present barriers and obstacles to collaboration across sectors and organisations (state and local government interview respondents).

Some identified barriers and obstacles to climate adaptation for human health more broadly were: a lack of information; lack of understanding of relationships between climate, health and epidemiology; lack of political will; scepticism of climate change health impacts; and apathy in the public (state and local government interview respondents; Gudes et al 2010; Huang et al 2011). Interestingly, finding synergies between climate adaptation options, and policy and strategy goals for the health sector as well as other sectors was suggested as a way of overcoming many of these obstacles and barriers. In response, some SEQ public health personnel are seeking ongoing working relationships with local government planners, and even undergoing tertiary training in urban planning in order to enhance opportunities for synergies between public health and urban planning (state government interview respondent).

> '*This whole notion of co-beneficial policy development is just so ripe for us to throw ourselves into but the silo mentality is just so entrenched*' (state government interview respondent).

Vulnerability assessment mapping for climate change risks, including consideration of thermal profiles, flood risks, land cover, population density, demographic indicators of sensitivity to health risks, and demographic and socioeconomic status indicators of adaptive capacity may be able to compliment decision support systems for health and urban planning agencies and assist in integrated and tailored strategies for specific locations and populations (Crick et al 2012; Mersereau & Penney 2008; CAP 2010). Information gained through stakeholder engagement can help contextualise and validate data generated by municipal agencies through Geographic Information Systems (GIS) mapping at a regional scale (Wilhelmi & Hayden 2010).

Although it does not include measures of climate vulnerability, merits of this approach are apparent in the Logan-Beaudesert Health Coalition and its Decision Support System which integrates a wide range of epidemiological, social and environmental features affecting health through a GIS interface accessible to urban planners, community representatives and health departments (Gudes et al 2010). These types of coalitions and collaborative arrangements, allow for regular information sharing and relationship-building across sectors and organisations as well as facilitating exchange of information, data and results of research, plus decision-making based on consistent data.

> "*We tend to - health expert kind of mentality where it's easy just to tell local governments what they need to do within their plans and what not, but in my experience, if you actually want stuff represented within plans you need to maintain really good relationships with local government planners*" (state government interview respondent).

- ***Communication and response***
    a. *What types of socio-economically and demographically relevant communication, response and surveillance systems are needed to better inform adaptation to health impacts of climate change in a pro-active manner?*

Generating greater public awareness and behaviour changes to avoid health risks is not a straightforward task due to differing perceptions of risks between vulnerable groups and policy makers and between different cultural and demographic groups (Iersel & Bi 2009; Basil & Cole 2010). Although public health alerts are generally widely received by the public, fewer people may translate them into behavioural changes (Bassil & Cole 2010).

Ebi and Semenza (2008) assert the importance of developing and testing awareness measures tailored specifically for vulnerable groups. In the SEQ local government context, there is evidence for a higher level of investment in research to understand perceptions of risk, measures to increase risk awareness to a range of natural hazards for different social groups across a metropolitan region such as SEQ. It was noted however, that this does not seem to be common practice at present (local government interview respondent). This may be viewed as a long term learning process for better public awareness relating to risk communication for environmental health and climate adaptation.

Current known potential climate change impacts on human health will need to be integrated with health surveillance and monitoring systems. Advances in understanding of relationship between climate and health will also need to be included over time (SMEC 2009; Spickett et al 2007). Surveillance systems that integrate monitoring of environmental, social and epidemiological features of health are recommended (Aagaard-Hansen et al 2009). The proposed adaptation options recommend surveillance systems that are accessible, and easy for multiple sectors and departments to draw on, and that allow health organisations (as well as other stakeholders) to recognise trends and forecast disease patterns and develop targeted preventative measures.

10.5.6 Areas for Future Research

As well as further research into integration of community-based initiatives and land use planning into public health planning, much baseline data is needed to monitor and to increase understanding of climate change health impacts. This further research and baseline data is needed in order to develop a better understanding of climate change health impacts spatially, temporally and with regards to their potential frequency, intensity and nature of impact. This is recommended with regard to both direct and indirect climate change health impacts, and includes considerations of the potential for climate change to affect social determinants of health (particularly mental health) – through loss of livelihood and/or disrupted social networks.

More specifically, this could include baseline data regarding heat stress and loss of productivity in workplaces in SEQ (Hanna et al 2011); and the implications of increased rainfall variability, and water demand management initiatives for human health (state and local government interview respondents). The need for further

research and environmental monitoring is captured in actions under human health Policy 4.

There is also clear evidence of the need for establishing a long term learning process to better understand public awareness relating to risk communication for environmental health and climate adaptation. A better understanding of perceptions of risk for measures to increase risk awareness of a range of natural hazards for different social groups has also been identified.

10.6 Whole of Human Settlement

Across the five Human Settlements sectors, a total of 21 policies have been proposed. Within these policies, some 95 programs containing 498 actions have been developed to address climate change adaptation in SEQ. The distribution of the various policies and their associated programs across the six human settlement types has been examined (see Table F1 in Appendix F - Relevance of Adaptation Policies & Programs to Human Settlement Types and SEQ Region). Table F1 shows a convenient way to group an appropriate set of human settlement sectors adaptation programs that may be required to address climate change in relation to one of the six generic human settlement types. A summary of the distribution of the adaptation programs across the human settlement types is provided in Table 13.

Table 13: Distribution of Adaptation Programs across Human Settlements Types

Human Settlement Type	Relevant Programs
Sandy Shores (beachfront high rise holiday destination)	45 programs
Blue Waters (canal estate)	48 programs
Greenhaven (middle suburb)	40 programs 22 duel programs*
Aussie Downtown (Regional Activity Centre)	40 programs 22 duel programs*
Alphaville (peri-urban community)	39 programs
Utopia (master planned community)	35 programs

(* Inland and Coastal)

The manner in which the adaptation options are reported against the *Greenhaven* and *Aussie Downtown* human settlement types is due to the possibility that these two types could be located in both inland and coastal locations in the SEQ context. Hence, the 'duel' programs refer to similar inland and coastal adaptation programs that can apply to them depending on their particular geographic location.

Overall there are 154 (plus 44 duel) adaptation programs that apply to inland circumstances compared to 173 (plus 44 duel) coastal adaptation programs. It should be noted that the same number of duel adaptation programs (i.e. 44) for both locations is merely a coincidence and it does not suggest that the same programs apply – in fact, whilst many are similar, they are comprised of difference sets of actions. Never-the-less, the grouping of adaptation policies and programs to human

settlement types shown in Table F1 can facilitate the speedy drawing together of suites of policies and programs for 'inland' as opposed to 'coastal' circumstances and locations.

The majority of adaptation programs are of a non-statutory (voluntary compliance) nature. There are some 21 adaptation programs (22%) that are associated with, or to be delivered through, statutory planning processes, largely in the urban planning and coastal management sectors. A further 16 (17%) can be classified as non-statutory and/or statutory planning related. Again, the grouping of adaptation policies and programs to human settlement types shown in Table F1 can facilitate a direct grouping of 'statutory planning related' programs in an efficient manner.

Naturally all of the proposed adaptation programs have relevance at the local scale (i.e. scale of the individual human settlement types) as well as the SEQ regional scale (*Lilliput*). All of these programs can also be applied to similar situations and circumstances beyond the SEQ region. However, some programs that are exclusively related to the regional scale, can also have a wider non-scalar context. Typical of this type are the 'capacity building', 'education' and 'training' programs which are consistently found in all sectors - these are indicated on Table F1 by an asterisk. Examples of these more generic programs which were not developed with any specific human settlement type in mind and have a wider than SEQ perspective includes:

UPM Program 3.1 Leadership Development
UPM Program 3.2 Capacity Building
UPM Program 3.3 Risk Communication on Climate Change
UPM Program 3.5 Professional and Sub-Professional Education and Training
CM Program 5.2 Enhanced Coastal Education Programs
CM Program 5.3 Enhanced Institutional Capacities to Manage Coastal Hazards
PI Program 3.1 Education
PI Program 1.3 Finance for Roads
PI Program 2.3 Finance for Stormwater Systems
EM Program 1.1 Long Term Post-Disaster Recovery Plan
EM Program 1.2 Post-Disaster Recovery in Pre-Disaster Plans
EM Program 2.4 Capacity Building and Training Program
EM Program 3.3 Real Estate Sector And Hazard Awareness
EM Program 4.2 Local Government Emergency Management Capacity
EM Program 4.4 Support Our Heroes
HH Program 2.4 Improved Availability of Information
HH Program 2.5 Leadership Development Through Collaboration
HH Program 4.1 Improved Understanding
HH Program 4.2 Risk Management and Population Health

Whilst many of the proposed adaptation options have been developed for the purpose that they can be implemented as individual initiatives, the overarching intent has been to consider an integrated, cross sectoral approach. Hence, the programs should be seen principally, not as individual stand alone initiatives but as having the potential to form part of a package or a suite of programs and actions that can be implemented to address climate change adaptation at: the local scale (i.e. individual

human settlement types); regional scale (i.e. SEQ/*Lilliput*); a broader than SEQ scale; or as previously discussed, in a non-scalar context.

For this purpose a further classification of the 95 adaptation programs has been completed which assesses their relevance to the eight adaptation themes (see Table F2: Relevance of Sectoral Programs to Adaptation Themes in Appendix F). As previously discussed, these eight adaptation themes are based on key messages elicited from stakeholder feedback (Low Choy et al 2012), document analysis and the literature and include:

1. Preparing the Community;
2. Support for Vulnerable Communities;
3. Leadership, including Community Leadership;
4. Proactive (Anticipatory) Initiatives;
5. Managing the (Urban) Environment;
6. Technological Development and Innovation;
7. Risk Communication[6]; and
8. Training and Education.

Whilst it is recognised that there is much overlap and duplication between these adaptation themes and the various programs, the latter have been assigned to a particular adaptation theme where it was considered to have maximum relevance. The key approach to overcoming the principal challenges for achieving successful adaptation to climate change that is characterised by its long term nature, its uncertainty, the associated evolving science and general lack of understanding in leadership and the community, will involve a concerted, continuous/continual and integrated (joined up) effort. To this end, the consolidation of various groupings of policies and programs into the adaptation themes can assist and commence to provide an insight into the implementation end of the adaptation process.

For the Human Settlements component, the implementation of its 21 policies and 95 programs containing 498 actions, consolidated as adaptation themes can be approached through a series of adaptation implementation phases that involve:

- Foundation Phase;
- Substantiation Phase;
- Mainstreaming Phase;
- Review Phase; and
- Consolidation Phase.

The original grouping of the policies and programs into the broad adaptation themes commenced the synthesis process and provided a sense of possible key strategic programs that could be contemplated to assist with climate change adaptation in the region. The assignment of these eight adaptation themes into a proposed sequencing arrangement comprised of five phases of adaptation implementation provides further insight into the requirements for implementation of potential strategies to address climate change adaptation of human settlements.

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[6] Risk communication proposed here involves full community engagement that ascertains the community's challenges, priorities and aspirations. It seeks to influence behaviour through better informed judgements and actions.

The proposed arrangement and sequencing of the eight adaptation themes across the various adaptation implementation phases are illustrated in Figure 11. Strong evidence has emerged, especially from stakeholder engagement supported by the literature, that well informed leadership that is confident in the adaptation process is essential (Low Choy et al 2012). For this reason, this suite of leadership programs is foundational to the successful implementation of all other adaptation options. However, a concerted effort will have to be made to achieve these ends and it will have to be a continual undertaking to address the churn that characterises the nature of leadership at institutional and community levels.

A further clear message from the stakeholder engagement was the need to ensure that there was continuity of effort as "*it was repeatedly noted that there had to be continuity of support, capacity building and programs to guarantee success particularly in a cost effective manner over longer time frames*" (Low Choy et al 2012: 42). In some cases this could be achieved as continuing initiatives, being ramped up as required, but in other instance it is clear that this effort must be continuous. A case-in-point is capacity building through training and education, managing the (urban) environment, and risk communication. These adaptation themes, along with leadership, underlie the 'Foundation and Substantiation Phases'.

By the 'Mainstreaming Phase', the relevant programs of all the adaptation themes should have been initiated and be operating in a coordinated and joined-up manner. The 'Review Phase' highlights the overarching approach that imbeds an adaptive management framework into the implementation process. Hence, there are a number of adaptive management cycles operating throughout the Human Settlements adaptation options. In addition to the 'Review Phase', an extensive range of additional adaptive management measures have been built into each program and associated actions. Subsequently, and subject to feedback and learnings from the 'Review Phase', the desired programs in their modified (or unmodified) form proceed through to the 'Consolidation Phase'.

It is important to reemphasise an earlier point of distinction that recognises that each location and circumstance is different (sometimes unique). Hence, not all individual programs and actions need to or will be included in all adaptation themes for specific cases of implementation. That said, it is also important to note that some programs can have a cross sectoral application. Examples of cross sectoral adaptation options that apply to all Human Settlements sectors include: risk communication; information sharing; capacity building and training; public awareness and education; leadership development; post disaster into pre disaster planning; planned retreat; physical and social infrastructure management; and adaptive management.

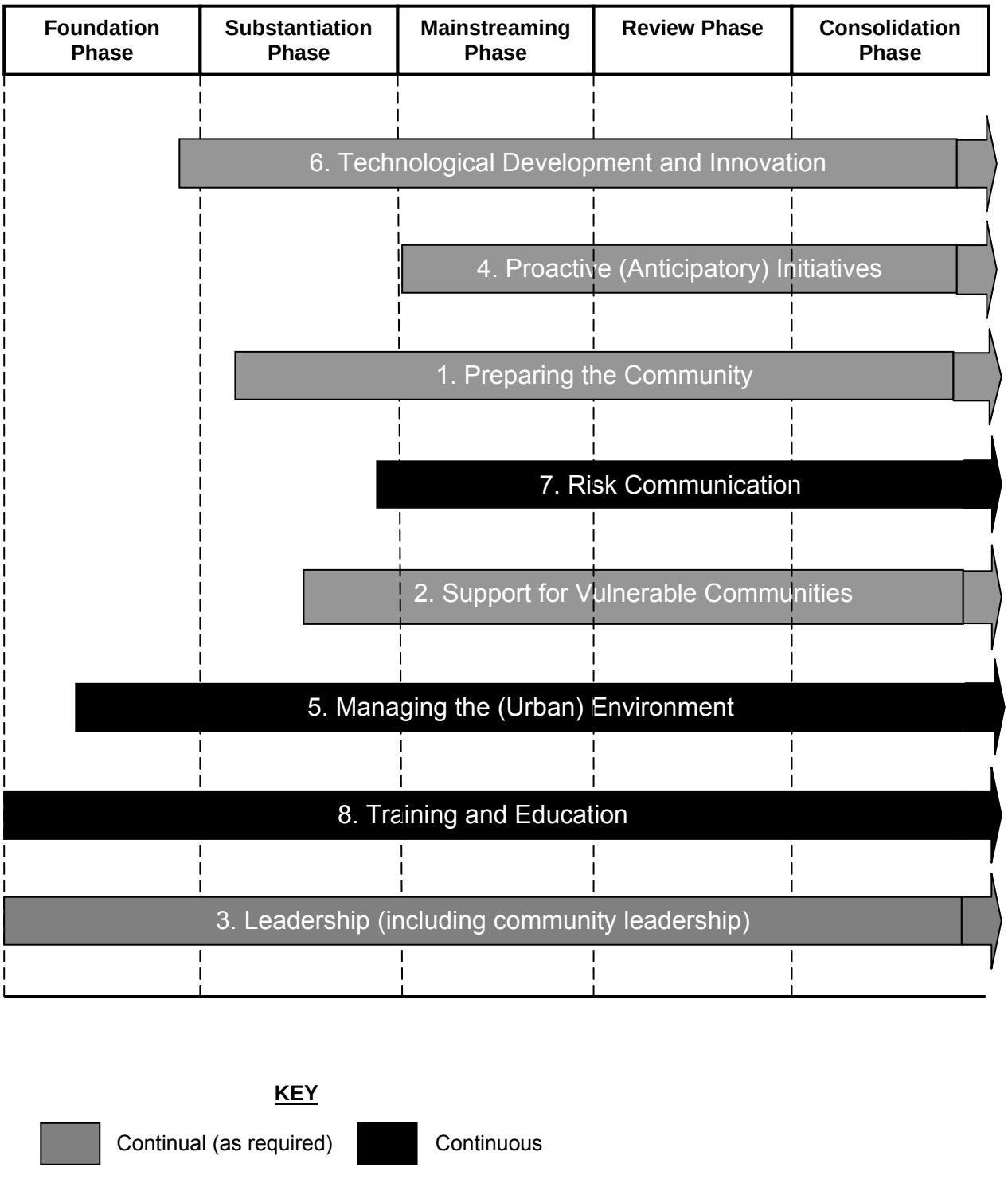

Figure 11: Phases of Adaptation Implementation

PART IV

11.0 DISCUSSION & RECOMMENDATIONS

11.1 Discussion

This chapter draws together the previous analysis and discussion and proposes a set of generic principles for human settlements climate change adaptation along with recommendations for future research at the whole of human settlements level.

It has been demonstrated that the process utilised to develop the Human Settlements adaptation options aligns with the previously discussed 'best practice' features for climate change adaptation and thus promotes the good decision-making principles of: a circular (adaptive) process; encourages feedback and iteration; and comprises tiered stages (see Chapter 3). It has also been demonstrated that these principles have been further reinforced through the design and development of the individual and collective frameworks for the Human Settlements adaptation options.

Each policy and program has been evaluated against the four 'What If' questions and the adaptation options evaluation criteria (see Chapter 9). These evaluations are recorded on all policy and program tables of each sector specific section of the Supplementary Report. These evaluations provide further insight into the responsiveness, robustness and the strengths and weaknesses of each policy and program.

The extensive stakeholder engagement completed by the Human Settlements team (workshops, interviews and surveys) supported by a comprehensive literature review and document analysis has highlighted a number of fundamental principles which should underlie any serious attempt at human settlements adaptation to climate change and natural hazards responding to the following **overarching goal**:

> *To minimise the region's vulnerability and risks from current and future climate change impacts, including the changing nature of natural hazards thereby assisting to establish resilient communities through the employment of appropriate community based adaptation strategies within statutory and non-statutory planning processes.*

These generic principles for human settlements climate change adaptation are set out and summarised below. They include:

1. Informed and confident political, private sector and community leadership;
2. An informed, engaged and prepared community;
3. Continuity of effort;
4. Full stakeholder engagement;
5. Holistic and proactive responses;
6. Integrated and coordinated action;
7. Mainstreaming of adaptive management practices;
8. Cascading local approaches within a regional perspective;
9. Targeted responses; and
10. Ongoing research.

1. Informed and confident political, private sector and community leadership: an essential pre-requisite for successful climate change adaptation is strong, positive and committed leadership at all levels in government, the private sector and the community. Strong leadership is required to improve the communication about climate change risks as well as establishing planning and decisions horizons that go beyond the duration of electoral cycles. This may at times include the need to intervene in order to ensure the success of adaptation options. These attributes of strong leadership should be informed through full community engagement processes and seek community partnerships for adaptation. Leadership of this nature requires the support of awareness, training, education and capacity building programs.

2. An informed, engaged and prepared community: complementary to strong community leadership is the notion of an informed, engaged and prepared community, inclusive of all citizens and visitors and not just property owners. The self empowering attributes of an engaged community can build social capital as it compliments strong leadership to jointly and successfully implement adaptation strategies to achieve the overarching goal of climate change adaptation and natural hazard minimisation. This requires a resilient community with high adaptive capacity capable of managing the risk from natural hazards especially during the response and recovery phases and seizing opportunities that arise as a consequence of climate change. This must be accompanied by a higher degree of community ownership and responsibility for local climate change adaptation. Informed and prepared communities need the support of awareness, training, education and capacity building programs.

3. Continuity of effort: initiatives supporting successful long term climate change adaptation, such as awareness, training, education and capacity building programs, need to be adequately resourced to maintain continuity of effort and message. The continuity and longevity of climate change adaptation initiatives, especially awareness and capacity building programs and campaigns, need to be of high quality, cost effective, targeted to specific groups and audiences, inclusive of vulnerable groups and presented in non alarmist terms to avoid negative messaging. The continuity of programs should seek longevity of initiatives with a particular embrace of a 'whole-of-life' perspective for investments, especially in physical infrastructure.

4. Full stakeholder engagement: a key factor that will be crucial to the success of any human settlements climate change adaptation campaign will be a significant commitment to stakeholder engagement which will lie at the core of the whole Human Settlements approach. This will entail the achievement of appropriate levels of engagement with and across key stakeholder groups that are representative of the community and its sectors in question. A high level of community engagement should be positioned in a bottom-up approach that facilitates a highly consultative partnership supporting, rather than be replaced by, strong leadership.

5. Holistic and proactive responses: comprehensiveness is the central theme of this principle which requires that climate change adaption actions be implemented through a joined up process that incorporates the interests and resources of the government, non-government, private and community sectors. In this regard it will

be essential to enlist the private sector in promoting adaptation which in turn may require the identification of incentives for adaptation to function within the open market. A holistic approach is required that extends well beyond the development of adaptation options and encompasses collaborative efforts such as: information, data and research sharing; consistent methodologies and tools for adaptation across human settlements; and streamlined integrated development assessment processes. These approaches will have a high degree of reliance on urban planning and management systems for implementation where it can promote both mandatory and/or voluntary adaptation. At the same time, the planning systems can provide a proactive stance to adaptation through its strategic planning focus. It will be essential to utilise the planning system as a core focus to enable effective cross sectoral adaptation where it can provide those critical links with and between all other Human Settlements sectors. A holistic and proactive approach to climate change adaptation requires that long-term disaster recovery considerations be integrated into pre-disaster planning processes.

6. Integrated and coordinated action: high degrees of collaboration will only be achieved if there is effective integration and coordination of actions that address horizontal and vertical linkages across a region or system. This calls for a 'whole of government' approach to the development and implementation of climate change adaptation policies, programs and actions which typically fall across a number of separate sectors. Efficient interoperability between agencies at all levels will be a key ingredient to achieving this intent. However, in view of the complexity of contemporary climate change adaptation and consistent with the overarching goal for Human Settlements adaptation, a more integrated and coordinated approach is now called for where the 'whole-of-government' model fits within a 'whole-of-community' approach. Achieving a 'whole-of-government' / 'whole-of-community' approach to climate change adaptation will require the planning system to play a key role in reducing the vulnerability of settlements and contribute to safer and more sustainable communities.

7. Mainstreaming of adaptive management practices: adaptive management approaches (incorporating the principles of circular; feedback and iteration; and tiered stages) are essential to deal with: the uncertainty associated with long term climate change; the evolving climate science; and the nature of system's feedback in learning and experience. Consistent with the requirement for continual improvement, an adaptive management approach can facilitate the periodic review and upgrade of policies, programs and actions in light of new knowledge and learnings. These improvements can only be maximised if adaptive management practices are mainstreamed into conventional day-to-day management processes and arrangements. To this end, the implementation phase of urban planning and management systems addressing climate adaptation should incorporate an adaptive management framework comprised of: performance indicators identification; monitoring and evaluation; reporting; and a formal learning component.

8. Cascading local approaches within a regional perspective: the effects of climate change and the impacts from natural hazards are most acute at local and regional levels. Local responses are required but they require a wider context to ensure that overlap and duplication are avoided and that maximum benefits are derived from collaborative and joined up adaptation initiatives. Institutional and

governance arrangements for planning and management along with decision-making processes for climate adaptation should ideally occur at both local and regional scales. Hence an integrated regional perspective is required to overarch adaptation programs and strategies where higher order initiatives can both support local initiatives and cascade down to those level in terms of support, guidance and direction. A regional perspective should also promote a higher degree of local adaptive capacity which is a necessary pre-condition to improving the planning decision-making process for climate adaptation at regional as well as local scales.

9. Targeted responses: climate change initiatives with the requirement for ongoing continuous communications and capacity building of a high quality should engage the whole community with the particular inclusion of vulnerable communities (including disadvantaged and marginalised groups, lower socioeconomic status populations and socially isolated individuals). This requires linked and up-to-date data bases where respective vulnerable groups can be readily identified and assisted. On another front and on another level, a targeted response will also encompass the development and implementation of particular adaptation options (e.g. 'planned retreat') only after extensive consultation and then at the discretion of affected but informed parties, which may at times kick in at the retirement of the affected assets.

10. Ongoing research: consistent with the spirit of continuous improvement leading to better and more informed decision-making and behaviour, an ongoing program of biophysical, engineering and social research (including technological development) will need to be resourced and maintained in order to keep abreast and ahead of the constantly changing nature of climate change and natural hazard events. Higher degrees of certainty for decision-making and behaviour can only come from improvements in scientific knowledge and a better understanding of the application of that knowledge to 'real world' situations and contexts.

11.2 Recommendations for further research

In addition to the sector specific recommendations for further research (see Chapter 10), a number of cross sectoral Human Settlements related recommendations are set our below.

Transferability of research findings: the opportunity to deconstruct the hypothetical case study and relate the findings back to real-world example sites is an option for future consideration. However, the generic nature of this inquiry through hypotheticals does theoretically facilitate their transfer to other similar situations and contexts. Further research is required to confirm how lessons learned about effective climate adaptation at the local level can be transferred to other locations and contexts. Such lessons can best be extracted once proposed adaptation options are implemented, monitored and reviewed, thereby requiring long-term longitudinal studies. Further development of cross sectoral frameworks of policies and programs should form part of this future research.

Better understanding of 'worst case scenarios': understanding the implications of worst-case scenarios especially with respect to coastal settlements and

infrastructures and vulnerable inland situations is a necessary undertaking to: confirm the adequacy of current and proposed adaptation options; to improve our understanding of (extreme) adaptation; and to identify gaps in response and recovery to natural hazards in particular. However the political sensitivities, technical difficulties and the uncertainty of climate science make this a challenging undertaking. Never-the-less, these aims could be achieved through approaches such as simulation, scenario planning or through onground exercises, especially involving the most vulnerable communities.

Understanding the recovery phase: further research is needed to better understand the recovery phase of disaster planning and management and in particular, the long-term and strategic aspects of recovery. In the past, the recovery phase has often been neglected by governments, agencies and the community at large. However, this phase is vital to breaking the disaster cycle and it has a key role to play in building resilience and adapting to climate change

Building social capital through adaptation: it has been suggested that climate change adaptation could have an added advantage of contributing to the building of social capital in the communities where adaptation is implemented. In view of the underlying philosophy behind the advocated guiding principles for human settlements adaptation, this is an issue that requires further research.

Potential for community partnerships and shared responsibilities: a major research agenda is emerging related to the concept of community empowered and initiated action for climate change adaptation and response to natural hazards. This concept extends to the notion of establishing shared responsibility and partnerships between communities and government agencies to address climate change and the impacts from natural hazards. These forms of initiative require research to better understand the concept, its formalisation into policy, its implementation opportunities and challenges for government and agency acceptance.

Enhanced role for urban planning: formal planning, particularly urban planning, is increasingly seen as the key link in the adaptation chain. Many recommendations centre around the need to link or integrate pertinent considerations of other Human Settlements sectors with urban planning. Allied to this approach is the fundamental requirement for the planning process to be informed by up-to-date and relevant baseline data to ensure the plans and policies are founded on the best available information. The enhanced role for urban planning extends to calls for integrating disaster risk management into planning and to integrate post-disaster recovery in pre-disaster planning. How these approaches can be operationalised and achieve the desired levels of integration sought requires research which should attract a high priority given planning's centrality to the whole question of human settlements adaptation. Research is also required to establish properly structured urban planning processes capable of providing a long term learning process through longitudinal monitoring and evaluations centred in an adaptive management framework.

Injurious affection: clearly, the successful implementation of a number of the adaptation options will require the serious address of the 'injurious affection' question by the state government, with the total support from local government. It was

previously concluded that this matter is a major stumbling block to the successful implementation on a number of the adaptation options. For this to happen, research is required to ground this requirement in the full human settlements climate change adaptation agenda.

Substantiating prescriptive adaptation options: further research is required to provide greater specificity to the proposed prescriptive and implementation measures of a number of the adaptation options, particularly those associated with the 'Building Code' and 'Infrastructure Design Standards'. This should extend to establishing a case for such adaptation that would receive industry and community acceptance.

Operationalising the precautionary principle and adaptive management approaches: it was considered worthwhile to explore the implications involved in adopting the Precautionary Principle when developing adaptation options. Notwithstanding the challenges of this undertaking, it was considered that this process could result in more effective climate adaptation strategies across regions and across sectors. This research could be linked to other research seeking to establish improved adaptive management approaches.

Innovation in design and method: consideration should be given to expanding the research into the feasibility of innovative adaptation options and designs for adaptation within the Queensland context across key human settlements sectors, (e.g. the use of rolling easements and other engineering design solutions).

12.0 CONCLUSIONS

This final phase, the subject of this report, has build on the study's previous seven phases which involved: the identification and preliminary desktop analysis of key issues for SEQ's human settlements; the selection, definition and description of appropriate case studies for closer examination of climate change; comprehensive literature reviews and document analyses in all five Human Settlements sectors; the development of preliminary adaptation options for the region and its six human settlement types; testing of preliminary adaptation options through a scenario planning process; and supplementary testing through further stakeholder engagement involving interviews, workshops and surveys. These preceding phases led to, and informed, the development of specific sectoral and cross sectoral adaptation options. This phase involved a significant cross sectoral Human Settlements team effort and investment to synthesise the research findings through a series of team retreats and internal workshops.

All the Project Brief's scope and intended outputs have been met along with the series of Human Settlements research questions. The three overarching principal project intentions that were relevant to the Human Settlements component (see Chapter 3) have been addressed and the final suite of adaptation options contains adaptation programs that satisfy these applied requirements. Likewise, the eight principal research questions (see Chapter 2), along with the sector specific research

questions (see Chapter 10), have been fully addressed with the exception of RQ 8 which can be wholly answered once a fuller understanding of the implementation of the proposed adaptation options has been achieved. The sectoral issues and trends previously identified in the first phase of the study and discussed Chapter 5 have been addressed by the 21 policies, 95 programs, and 498 actions that have been developed across the Human Settlements component.

This study has been the first comprehensive regional study of climate change adaptation in Australia, and one of just a few worldwide. Its comprehensive nature is borne out through its coverage of the five principal Human Settlements sectors of: urban planning and management; coastal management; physical infrastructure related to local government; emergency management; and human health.

It is critical that relevant combinations of the proposed adaptation options, in the form of policies, programs and actions for each of the five sectors, are implemented to minimise SEQ's vulnerability to future climate change impacts, including natural hazards. Failure to implement the appropriate adaptation options will continue to place the region, its settlements and population at risk. Furthermore, it could also lead to significant economic, social and environmental losses with further consequences for both the region's liveability and sustainability.

The lack of scientific knowledge, the uncertainty associated with climate science and future risks from natural hazards, and the political sensitivities in dealing with climate change should not continue as a barrier to effective adaptation and delay the implementation of robust measures of adaption action to climate change with respect to human settlements which are characterised by major investments, long planning timelines and potentially vulnerable communities. This study has demonstrated that these barriers can be overcome through research strategies involving hypothetical case studies operating through a comprehensive scenario planning process. Participants involved in the extensive stakeholder engagement achieved in this Human Settlements study have also had opportunities to extend and improve their respective individual and institutional adaptive capacity to address climate change adaptation.

Whilst all of the adaptation options have been developed to address climate change, many of the recommended adaptation options represent **'no-regrets' options** where their implementation would contribute to improvements in the community, the landscape and society generally, regardless of climate change impacts. Thus it will be essential to identify particular 'no-regret' options (on a case by case basis), relevant to the particular case and circumstance when advocating for the funding of adaptation option packages.

Underpinning the whole Human Settlements approach to climate change adaptation is the notion of informed and confident political, private sector and community leadership, supported by an informed, engaged and prepared community that are reinforced through continuous awareness, training, education and capacity building programs that operate in a process of full stakeholder engagement leading to mutually agreed actions. These initiatives are occurring in a process characterised by holistic and proactive responses and integrated and coordinated action, operating

within mainstreamed adaptive management practices where a regional perspective cascades to local approaches which incorporate targeted responses. All of these initiatives are supported by ongoing research.

The Human Settlements research has resulted in rich and extensive data, much of which continues to be analysed. It is intended that these outcomes will be fully reported in peer reviewed journals and other publications in the near future.

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APPENDIX A: HUMAN SETTLEMENTS TEAM

Professor Scott BAUM (PhD, BA (hons), B Ec) is Professor in the Griffith School of Environment, Griffith University. Trained in Economics and Sociology Professor Baum's research interests focuses on understanding community vulnerability to social, economic and environmental stressors including the impacts of climate change. Over his career he has been involved in competitive research grants totalling in excess of $11m as either lead investigator or co-investigator. He has published in excess of 100 academic papers, chapters and books. As part of the Human Settlements team of the SEQ CARI project he led the health research.

Dr. Florence CRICK is a Research Fellow at the Urban Research Program, Griffith University. She completed her PhD at the University of Oxford and subsequently worked in the OECD Environment Directorate, Paris as a climate change adaptation consultant, then the National Climate Change Adaptation Research Facility, Australia, as a Research Coordinator. Dr. Crick has expertise in the social and institutional dimensions of climate change adaptation. Her experience spans multiple scales from international and national climate change adaptation policy to community based adaptation and local livelihoods. She is a member of a team investigating strategic post disaster recovery for coastal communities. She leads the emergency management research component of SEQ CARI.

Ben HARMAN is an Environmental Planner with CSIRO Ecosystem Sciences based in Brisbane. His research interests include: urban and regional planning (including urban governance and policy making), natural resource management, peri-urbanisation, and climate change adaptation. Ben has a keen interest in understanding the relationship between science and planning. His primary role in the SEQ CARI project has been to assist key researchers within Griffith University in relation to the urban planning and management sector.

Dr Darryl LOW CHOY is Professor of Environmental and Landscape Planning in the School of Environment, Griffith University. He is currently leading research into climate change adaptation for peri-urban and urban Indigenous communities; peri-urbanisation and the management of invasive animals; strategic post disaster recovery for coastal communities; and the incorporation of indigenous landscape values into regional planning processes. He is also leading research into catchment scale landscape planning for water sensitive cities in an age of climate change in the new Cooperative Research Centre for water Sensitive Cities. He leads the Human Settlement research team of the SEQ CARI.

Dr Marcello SANÒ is Research Fellow at Griffith Centre for Coastal Management, specializing in coastal planning, management, engineering, climate change adaptation, coastal ecosystems and community engagement. He holds a PhD at the Civil Engineering School of the University of Cantabria, Spain and an MSc in Environmental Science from the University of Genoa, Italy. His activities within the

SEQCARI project include the assessment of the vulnerability of coastal settlements at different scales, the assessment of the coastal policy frameworks and the development of climate change adaptation options for coastal management.

Dr Oz SAHIN holds a BEng degree in Industrial Engineering, and received his Masters of Engineering and PhD degrees from Griffith University. His research interests include integrated decision support systems using coupled systems dynamics - GIS modelling and multiple criteria decision analysis techniques. Dr Sahin led the physical infrastructure sector (stormwater) of the Human Settlements component of SEQ CARI. His research focused on developing an adaptation framework to prepare stormwater systems and management for the impacts of climate change. As part of his research task, he also conducted multi-criteria analyses to evaluate adaptation options by involving multiple-stakeholders across three regions in SEQ.

Dr Silvia SERRAO-NEUMANN is a Research Fellow in the Urban Research Program, Griffith University, Brisbane. Her role in the SEQ CARI is the investigation of climate adaptation related to human settlements focused on urban planning and management. She is also a member of a team investigating strategic post disaster recovery for coastal communities. Before joining the Griffith University and SEQ CARI, she worked for the Queensland Government for seven years in the field of environmental education.

Dr Rudi van STADEN, a Research Fellow in the Griffith School of Engineering, co-led the Physical Infrastructure sector. He has particular expertise in mechanical engineering and computational mechanics. His research tasks involved the development of a PI adaptation framework to help address climate change realities in SEQ. Formulation of this framework involved a detailed review of the current policies and programs of local governments and substantial stakeholder engagement. A showcase study was also performed using the Finite Element Method to improve the understanding of climate change impacts on road deterioration and associated design and maintenance implications.

Gemma SCHUCH is a Senior Research Assistant at the Urban Research Program, Griffith University. After completing a Master of Urban and Environmental Planning, she worked on issues of climate change advocacy in the community sector in Brisbane. This was followed by work in agricultural climate adaptation within a community and international development context in the Philippines, working with small scale farmers as an AusAID Youth Ambassador for Development, and as an intern with the Centre for Communications and Social Change on climate change adaptation proposals. In the Human Settlements component of SEQ CARI, she researched climate change adaptation in relation to the human health sector.

APPENDIX B: EXISTING NATIONAL, STATE, REGIONAL & LOCAL PLANNING & POLICY INITIATIVES RELATED TO CLIMATE CHANGE ADAPTATION IN SEQ

Table B1: Overview of the incorporation of climate change adaptation in key instruments at the state/ SEQ regional level

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision)
Sustainable Planning Act 2009		• Purpose (s5 (1)(a)(ii)) - "take account of short and long term environmental effects of development including, the effects of development on climate change"
SEQ Regional Plan 2009-2031	●Desired Regional Outcome (DRO) 1. Sustainability and Climate Change ○DRO 1 - 1.3 . Reducing Green House Gas Emissions ●DRO 1 - 1.4. Natural Hazards and Climate Change Adaptation ●DRO 2 – 2.1. Biodiversity ○DRO 2 – 2.4 Managing the Coast •DRO 6 – 6.1 Social Planning •DRO 8 – 8.1 Compact Development ○DRO 8 – 8.2 Containing Growth ○DRO 8 – 8.4 Urban Greenspace ○DRO 8 – 8.6 Activity Centres and Transit Corridors ○DRO 8 – 8.9 Integrated Land Use and Transport Planning ○DRO 10 – 10.4 Protecting Key Sites and Corridors ○DRO 10 – 10.7 Waste ○DRO 11- 11.1 Total Water Cycle Management ○DRO 11- 11.2 Water Supply Planning ●DRO 11- 11.6 Overland Flow and Flood Management ○DRO 12-12.1 Integrated Transport Planning ○DRO 12- 12.2 Sustainable Travel and Improved Accessibility ○DRO 12-12.3 Effective Transport Investment ○DRO 12- 12.4 Transport System Efficiency	• Regional Vision; "a future that is sustainable, affordable, prosperous, liveable and resilient to climate change"
Draft SEQ Climate Change Management Plan 2009	Draft Actions ○5.2 Reducing greenhouse gas emissions – integrated transport and land use planning, TODs; energy efficiency in housing and urban design, energy sources; carbon storage; waste emissions ●5.3.1 Coastal hazards – Program K - reduce vulnerability and exposure of communities, essential infrastructure and development ●5.3.2 – Riverine flooding, bushfire, high temperature and other natural hazards – Program L - reduce vulnerability and exposure of communities, essential infrastructure and development ●5.3.3 – Biodiversity conservation – resilience of natural ecosystems to climate change ●5.3.4 – Climate Change Adaptation Research ●5.3.4- Build social resilience	
Climate Change Adaptation	●4.2 – Human Settlements - Current actions - Coastal Plan; Inland Flooding Study; Planning	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision)
Issues Paper	instruments; Building Standards; Water by design Future actions - Planning, building design and flood risks; Sea level rise estimate, High risk coastal areas; Risk Allocation (incl. high impact/ contentious policies); Private insurance ●5.3 – Infrastructure – Current actions – Climate Change Impact Statement; rebuilding more resilient; impact of coastal hazards on transport network Future actions – risk assessment of government assets; critical infrastructure and interdependency; collaboration between private owners and operators; flood mitigation; design criteria; new climate resilient material and design ●6.3- Biodiversity – Current actions – vegetation management; increased protected area; corridors; fire management; Biodiversity Strategy Future actions – improved knowledge base; adaptive management; assessing ecosystem services; harnessing carbon ● 7.3 – Water Management – Current actions - Water resource and operations plans; regional water supply strategies; SEQ water grid; Hydrological modelling and climate change; Water Efficiency Management Plans Future actions – diversification of water resources Also include actions for EM and Health sector	
Queensland Coastal Plan	<u>State Policy for Coastal Management</u> Specific Policy Outcomes ○ 1 Protecting coastal processes in erosion prone areas – land stabilisation through native vegetation; natural fluctuations allowed to occur; beach nourishment, maintenance of dune crest height ○ 2 Buildings and structures in erosion prone areas - locating buildings outside risk areas; buildings to be temporary or relocatable; beach nourishment; limited engineering solutions; shoreline management plans ○ 3 Dune management – long-term stability and maintenance; protection of dune vegetation; location of facilities outside dunal area; beach reprofiling/buffer zones ○ 4 Management of areas of ecological significance – protect habitats; improve habitat connectivity • 6 Public access and use of the coast – limited building of new public facilities • 7 Buildings and structures on State coastal land - limited building of new public facilities; climate-sensitive design ○ 9 Management planning – local area coastal management plans State Planning Policy for Coastal Protection Policy Outcomes ● 1. Land Use Planning – 1.1 infill development and minimisation of development in the coastal zone; 1.2 nodal settlement pattern; 1.3 constrain development in areas of medium and high coastal hazards; 1.6/7/8 coastal hazard adaptation strategies in planning schemes for localities under high coastal hazard by 2100 ● 2. Coastal Hazards – 2.1 definition of coastal hazards area (0.8m sea level rise and 10% increase in cyclone intensity); 2.2 review methodology after release of IPCC report or Commonwealth guidelines; 2.3 locate development outside erosion prone area or being relocatable; 2.4. Coastal protection works – aligned with shoreline management; beach nourishment over control structures; 2.5 development to be locate outside high and medium coastal hazards areas • 3. Nature conservation – location of development outside areas of high ecological significance	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision)
	○ 7. Canal and artificial waterways – to occur only within a maritime development area	
Mitigating the Adverse Impacts of Floods, Bushfire and Landslide	Policy Outcomes •1. Development to be compatible with nature of natural hazards in identified hazard management areas •2. Minimise impacts from natural hazards on development •3. Community infrastructure to function during and after natural hazard •4. Planning schemes identify hazard management areas •5. Planning scheme ensures outcome 1 and 2	
ClimateQ: Toward a Greener Queensland 2009	Policy Approach ○10 Energy ○12 Planning and Building ○13 Community reducing carbon footprint ○15 Transport •16 Ecosystems	
ClimateSmart Adaptation 2007-2012		Principles •1. Adaptation actions contribute to sustainability ○ 2. Adaptation actions do not replace efforts to reduce GHG emissions ○ 3. Actions consider the emissions they may generate •4. Working in partnerships is fundamental to success

Legend: ◦ not addressing climate change adaptation; • partially addressing climate change adaptation; ● substantially addressing climate change adaptation directly; ○ substantially addressing climate change adaptation indirectly

Table B.2: Overview of the incorporation of climate change adaptation in key instruments of the Gold Coast City Council

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
Bold Future Planning Scheme Statement of Proposal (including post-consultation report)	(post- public consultation) ●6.1 – Integrating climate change into the planning scheme ◦6.3 – Planned Future Growth Areas ◦6.6 – Integration of Social and Community Infrastructure ◦6.7 - Quality and design of the built environment (residential and commercial) and transect planning	(pre- public consultation) ● Identifies climate change as a key issue to be addressed in the new planning scheme with focus on natural hazards (flood, landslip and bushfire) and future climate change risks. Highlights the need to partner with state agencies to identify long-term risk areas, particularly with regard to sea level rise and storm surge to guide development in those areas. ○Also focuses on mitigation through reducing greenhouse gas emissions in the transport sector ○Parks and open spaces – taking into consideration street trees to contribute to cooling effect ○Biodiversity and wildlife corridors – consolidation of critical corridors, retention of existing vegetation and rehabilitation of other areas ○Water and waterways – buffer for developments, riparian corridors ○Beaches and coastline – protection of coastal systems ○Choice of attractive and desirable environmentally-friendly modes of travel ●Safe and secure community – manage impacts of natural hazards and climate change, limiting further development in areas at risk ◦ Health and education services ◦Food Production – location of food production in urban and rural areas ◦Corridors and buffers – particularly infrastructure corridors ◦The basis for a sustainable community – development intensity near public transport facilities and employment hubs ○ Housing – energy efficient design ◦Infrastructure is planned and delivered to meet the needs of the growing community – including size, type, timing and location of areas planned for future growth ●High quality urban design, world-class city image and diverse built forms – water management taking into consideration climate variability as well as being energy efficient
Gold Coast Planning Scheme	(Key Strategies) ◦ Nature Conservation – location, scale, density and nature of development consistent to conservation strategy ; protection of ecologically significant areas ◦Growth Management – infill development and location of areas for future development ◦Infrastructure Planning and Provision – infrastructure delivery for	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
	future development ◦Tourism – character of the area , diversification of industry ◦Natural Resources – ensuring water supply and quality ◦Housing – location of housing to aged population, design •Transport – energy efficient, maintenance of road network ○Energy Conservation – land use form and pattern leading to individual energy conservation, energy efficient developments, renewable energy sources in new developments ◦Community facilities •Waster – encouraging recycling and reduction of waste generation ○Natural Hazards Mitigation – restriction of development in areas at risk, reducing risk to existing developments through disaster management and public health and safety ◦City Image and Townscape – natural and physical features to be maintained (Performance Indicators – Desired Environmental Outcomes) ◦ DEO 1 – Ecological Processes – conservation of areas of high ecological significance, coastal ecosystems, buffer areas, corridors; waterways health and water quality, riparian vegetation, wetlands; • air quality by reducing greenhouse gas emissions , waste production ◦DEO 2- Economic Development – increase residential density, protecting tourist attractions, provision of major infrastructure, ◦DEO 4 – Community Wellbeing – urban form and residential densities, minimisation of environmental harm •location and design of development to take risks of natural hazards into account, mitigation of risks through design and disaster management	
Gold Coast Corporate Plan 2009-2014	●key focus area 1 – city leading by example – in 2040 city is resilient, adaptive and maximise the opportunities presented by emerging challenges such as climate change; 1.4 – city-wide planning to respond to risks and opportunities from climate change ●key focus area 2 - 2.3 Wildlife corridors – protect biodiversity and mitigate risks of climate change; 2.4 Ensure coastline, beaches and ocean can adapt to climate change; protect beaches from storm activities and urban development; ○2.5 resilience of waterways to impacts from flooding and storm surges; ○2.6 reduce carbon emission through improved waste management ○key focus area 3 – 3.2 public transport and environmentally friendly	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
	modes of travel ○key focus area 4 – 4.1 community gardens and food security; 4.2 maximise disaster management response; welfare Programs tailored to disasters and emergencies; 4.3 maximise quality of public health services; 4.5 maximise social infrastructure ○key focus area 5 – 5.4 promote green energy industry	
Southport Central Master Plan	○3.7 Medical Knowledge and Education research to focus on climate change ○4.5 - Provision of social infrastructure (linked to health and EM facilities) ●5.2 – Future development of Broadwater foreshore to consider climate change impacts ○7.4 – Reduce energy consumption generated by coal and encourage renewables ◦9.2- Land use and density; ○9.4 Building design (mitigation but nor climate change risks)	●Need for consideration of climate change risks included in the introduction
Climate Change Strategy 2009-2014	●4.4.1 – leadership for local actions on climate change ○4.4.2 –Opportunities and technologies associated with climate change ●4.4.3 – research to support climate change response ●4.4.4/5 – Advocacy and awareness at decision-makers and community levels ●4.4.6 – Infrastructure resilience ●4.4.7 – Climate change considered in council's statutory obligations	
Sustainable Flood Management Strategy	○4.2.1 – Reduce flood risk for the community ○4.2.5 - Adaptable and future-proof flood risk management approaches ○4.2.6 – Community awareness and resilience to flood impacts ○4.2.8 – Appropriate design, construction and maintenance of critical infrastructure	●executive summary refers to uncertainty of climate change and need for adaptive management; clearly links flood risk to climate change and potential future increase in flooding
Ocean Beaches and Foreshores Strategy 2010-2019		

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
Gold Coast Shoreline Management Plan		
Nature Conservation Strategy	●5 – Adaptive management to respond to climate change risks ●6 – Partnerships - assessment of impacts and adaptation strategies related to conservation networks ●Conservation management units to adapt to climate change, e.g. core habitat systems, critical corridors, multipurpose areas (canelands)	●Executive summary acknowledges climate change threats to city's ecosystems

Legend: ◦ not addressing climate change adaptation; • partially addressing climate change adaptation; ● substantially addressing climate change adaptation directly; ○ substantially addressing climate change adaptation indirectly

Table B.3: Overview of the incorporation of climate change adaptation in key instruments of the Moreton Bay Regional Council

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
Caboolture Shire Planning Scheme	Desired Environmental Outcomes ◦Proposes infill development near the foreshore where appropriate and within urban consolidated areas •Areas of ecological significant to be protected •Minimise effects of natural and man-made hazards on natural environment and communities	
Pine Rivers Planning Scheme	Desired Environmental Outcomes ◦Economic Development - DEO 1 – Urban Corridor - Intensification of development in designated urban corridors •Ecological Processes and Natural Systems – DEO 1 – Terrestrial Ecosystems - Maintenance of biodiversity and existing terrestrial ecosystems unless demonstrated overriding public benefit; •DEO 3 - Water Quality – Storage - Water and waterways quality to be protected •Community Wellbeing - DEO 1 – Community Needs - Availability of community facilities with easy access; •DEO 5 – Public Health and Safety - Minimise risk exposure of development to natural hazards	
Redcliffe City Planning Scheme	Desired Environmental Outcomes •(E) - Areas of ecological significant to be protected •(L) – Minimise risk of development to natural hazards as per SPP	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
	1/03	
Corporate Plan 2009-2014	Outcomes ○Sustainable management and protection of natural environment – reduce carbon emissions Appendix 1 – regional issues ●Improvement of disaster management to deal with climate change impacts: storm surge and local flooding due to sea level rise and severe storms ●Environmental management to consider climate change impacts, development of adaptation strategies ●Impact of sea level rise on infrastructure acknowledged ●Increase in vector-borne diseases due to climate change	
Climate Change Policy		●Council projects, processes and programs to consider climate change implications
Scoping Climate Change Risk for MBRC	●Areas of exposure identified within council business include: asset planning and delivery, asset management and construction, community and cultural services, strategic planning and development, water supply, environmental and local laws, corporate services and office of CEO. ●Themes suggested as part of adaptation options included: working group, climate change risk, risk assessment, council's plans, adaptive capacity, government responsibilities, development, multiple impacts, economic resilience, community awareness, funding sources.	
Sustainability Policy		◦No reference to climate change
Urban Stormwater Management Strategy Report 2002	Action Plan •4.1 - Manage stormwater quantity - ongoing flood studies •4.3 - Maintain stormwater systems	•Directly linked to flood mitigation
Caboolture Shire Natural Disaster Risk Management Study: Draft Report Executive Summary	●Key natural hazards, including climate change, to affect the area with associated historical information are identified; identify that developed properties, population, lifeline infrastructures, economy and environment are acknowledge to have exposure to natural hazards;	

Legend: ◦ not addressing climate change adaptation; • partially addressing climate change adaptation; ● substantially addressing climate change adaptation directly; ○ substantially addressing climate change adaptation indirectly

Table B.4: Overview of the incorporation of climate change adaptation in key instruments of the Ipswich City Council

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
Ipswich Planning Scheme	Desired Environmental Outcomes •(a) Areas of ecological significant not to be compromised •(h) Maximise efficiency and extension of existing infrastructure •(i) minimise impacts of natural hazards, e.g. floods, bushfire and land subsidence	
Ripley Valley Structure Plan	Infrastructure and Services •3.2.2 – Total water cycle management – (2) stormwater management ○3.2.3 – Transport, mobility and access – reduce carbon emissions (mitigation) ○3.2.4 – Energy – use of renewable sources (mitigation) •3.2.7 – Community facilities – easy accessible location	
Ipswich City Council Corporate Plan 2007-2012	Strategic Priorities •NE 1 Protection of Biodiversity •NE 3.1 – Integrated catchment management ◦GM 1.2 – Infill development ○GM 5.1 – Climate responsive building design (mitigation) •IS 1.6 – Maintain and upgrade infrastructure to meet community needs ○IS 4.2 – Use of renewable energy ○ITM 5 – Minimise use of private vehicle (mitigation) (also items related to EM, Health and asset management)	●Climate change identified as one of key trends and drivers
Nature Conservation Strategy	Actions and Themes •11.2.1 – Conservation state – land acquisition and management •11.2.2 – Rural ecology – voluntary co-operative program •11.2.3 – Nature conservation in urban areas - urban corridors	●Climate Change identified as a threat
Waterway Health Strategy		•Climate change impacts presented in appendix but not in main text

Legend: ◦ not addressing climate change adaptation; • partially addressing climate change adaptation; ● substantially addressing climate change adaptation directly; ○ substantially addressing climate change adaptation indirectly

Table B.5: Overview of the incorporation of climate change adaptation in key instruments of the Sunshine Coast Regional Council

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
Planning for a Sustainable Sunshine Coast. Key Issues Report (post consultation)	Key Issues •2.1 – 1- Environmental Protection and Rehabilitation ◦2.3 – 9 Infrastructure, infill development linked to new hospital facility ◦2.8 - 8 – Increased density ○2.6 – Reduce car dependency	●Climate change to be considered in land use allocation
Planning for a Sustainable Sunshine Coast (Statement of Proposals)		●Responding to climate change indentified as key challenge Supporting Themes ●4.1 Managing Growth – urban development to avoid areas at risk of natural hazards and climate change ◦ Consolidation of development – infill development ●4.3 Ecological Sustainability – reduction of carbon footprint, protection and rehabilitation of areas of ecological significance ○4.5 Social cohesion – reduction in energy and water consumption, provision of social infrastructure, urban agriculture ○4.6 Accessibility and connectedness – sustainable transport network
Caloundra City Plan	Desired Environmental Outcomes •2.4 Protection of natural assets and systems ○2.6.1- Access and Mobility – reduce private vehicle dependency ◦2.7 – Infrastructure – Increase urban density; •allow for flood carrying capacity	
Maroochy Plan	Desired Environmental Outcomes •2.2 - 1 - Environmental Management - Protection of ecosystems ◦2.7 – Urban design, heritage and character Strategies ◦3 – Urban development •13 – Transport ◦14 – Physical infrastructure ●16 – Stormwater drainage and floodprone land - limitation of further development in floodprone land	
The Noosa Plan	Desired Environmental Outcomes •(g) Open Space, environment and conservation functions – protection of ecosystems Strategic Framework ○1.7.6 Residential development – energy and sustainability; ◦urban consolidation and higher densities	

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
	•1.7.12 – Natural environment protection •1.7.14 – Natural hazard management ○1.7.17 – Transport infrastructure (reduce car dependency)	
Climate Change and Peak Oil Strategy	Action Plan ●1 – Leadership and best practice - 100 year planning horizon; mainstream climate change; reporting, monitoring and measuring mechanisms; duty of care ●2 – Build capacity for Council and community – institutional knowledge capital; community engagement and empowerment; partnership and advocacy ○3 – Carbon neutral organisation – council operation; waste management; transport emissions; energy consumption and type; offset emissions ○4 – Reduce community's emission – knowledge base; promote low carbon community; transport and land use planning; building and housing choice ●5 – Climate risks – regional risks and vulnerabilities; effective land use planning; disaster planning and health; coastal management ●6 – Climate adaptation – resilience of natural landscape; reduce water demand; reduce risk to assets and infrastructure; other opportunities ○7 – Reduce oil dependency – regional risks and vulnerabilities; energy transition; council's footprint; localised solutions; alternative transport modes ○8 – Maximise investment in low emission and renewable technologies – alternative energy sources; low impact business; sustainable investment; diverse local economy	Strategic Framework (goals) ●Low carbon, low oil, resilient future – leadership, mitigation, adaptation and energy transition
Energy Transition Plan	Action Plan ○ Council leadership ○ Economic diversification and energy investment ○ Sustainable transport ○ Local food supply ○ Clean energy ○ Household energy	
Sunshine Coast Growth Management Position Paper	Strategies •4.1 Residential strategy – respect biophysical constraints; ○ design to reduce ecological footprint; ○ heat island effect offset •4.3 Open space strategy – maintain ecologically important areas; wildlife corridors	Links to issues from the Regional Plan, including climate change

Instrument	Principles, Policies, Programs and/or Actions	Others (Objectives, Vision, Issues)
	○4.4 Integrated transport strategy – sustainable transport to cope with peak oil •4.4 Infrastructure strategy – social infrastructure; ○sustainable infrastructure technologies to reduce carbon emissions •4.7 Regional landscape strategy – natural hazards management	
Sunshine Coast Sustainable Transport Strategy		○3.4 Management of climate change impacts is identified as a challenge – strategies related to mitigating impacts through reduction of carbon emissions in the transport sector
Sunshine Coast Biodiversity Strategy 2010 - 2020	Strategic directions ●Resilience to climate change built through legal mechanisms, partnership and community engagement, protection and rehabilitation, pest management, new and emerging tools (green infrastructure), building knowledge, integrated catchment management aimed at enhancing and connecting areas of biodiversity value	○4.4 Climate change identified as a threat to biodiversity Vision ●5.1 - By 2020 the region's biodiversity is protected, enhanced, healthy, resilient to climate change and valued by the entire community.
Sunshine Coast Regional Council Corporate Plan 2009-2014		Themes ●2.1 Climate change impact, including developing adaption and mitigation actions ○4.1.4 Disaster management
Sunshine Coast Social Infrastructure Strategy 2011	Strategies and actions ○Outcome 1 – Strong network of community hubs	
Sunshine Coast Waterways and Coastal Management Strategy 2011-2021	Strategic Directions • Natural Waterways – natural waterway management to consider climate change ● Coastal Foreshores – allow natural fluctuations to occur due to climate change; integrated coastal management to address climate change; shoreline erosion management; community informed about climate change impacts; defend/adapt/retreat to climate change with community input	Challenges ● 4.2 Preparing climate change impacts ● 4.7 Maintaining riparian and in-stream health ● 4.9 Managing coastal hazards

Legend: ◦ not addressing climate change adaptation; • partially addressing climate change adaptation; ● substantially addressing climate change adaptation directly; ○ substantially addressing climate change adaptation indirectly

Table B.6: Overview of the incorporation of climate change adaptation and/or Emergency Management in key instruments at all levels

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
NATIONAL	National Strategy for Disaster Resilience	'Action 1': Leading change and coordinating effort 'Action 2': Understanding Risks 'Action 3': Communicating with and educating people about risks 'Action 4': Partnering with those who effect change 'Action 5': Empowering individuals and communities to exercise choice and take responsibility *'Action 6': Reducing risks in the built environment* *'Action 7': Supporting capabilities for disaster resilience*	• Action 2 priority outcomes: risk assessments consider risks and vulnerabilities and capabilities across the social, economic, built and natural environments • Action 3 priority outcomes: communities supported through appropriately targeted training and awareness activities • Action 5 priority outcomes: accurate and authoritative risk information is provided, tailored to the needs of the audience, and the tools to interpret and act on that information are available; significant providers of goods and/or services to the community undertake business continuity planning • *Action 6 priority outcomes: following a disaster the appropriateness of rebuilding in the same location, or rebuilding to a more resilient standard to reduce future risks is adequately considered by authorities and individuals* • *Action 7 priority outcomes: local planning for the response to and recovery from disasters will take account of community vulnerabilities and incorporate DRR measures; recovery strategies are developed in partnership with communities and account for long term local needs and provide support and tools to manage their exposure to future disasters; post disaster assessments involving all stakeholders are routinely undertaken to consider the effectiveness of PPRR activities and operations.*
	National Disaster Resilience Framework	• Principle 1. Shared understanding of disaster risk, its context and responsibility for its management • Principle 2. Comprehensive approach to increase disaster resilience • Principle 3. Nationally integrated approach to implementing framework – EM sector must engage collaboratively with other sectors Components of framework: • Leadership and coordination • Communications – engaging individuals and communities at grass roots level to understand disaster risks and share ownership of those risks • Awareness of risk environment – includes climate change • Partnership with those who effect change – private sector and NGOs	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		• Empowered individuals and communities – more self-reliant individuals and communities • *Reducing disaster risk through appropriate development in the built environment – consider current and future disaster risk in urban and regional planning; clear need for EM sector to engage with and influence a broader set of policy levers in other parts of government, incl. CC policies, land use planning policies, etc...* • Flexible, adaptable capabilities for response to and recovery from disasters • Regional countries with capacity and resilience • Supporting plans: incl. Climate Change Action Plan	
	National Partnership Agreement on Natural Disaster Resilience	No mention of CC • Objective: Australian communities that are resilient to natural disasters • Outcomes: a. Reduced risk from the impact of disasters; b. Appropriate emergency management capability and capacity, consistent with State and Territory risk profiles; c. Support for volunteers • Role of States and Territories: produce a state/territory wide prioritised natural disaster risk assessment in accordance with the relevant Australian standards; in conjunction with the Commonwealth, develop and jointly agree annual Implementation Plans of how they will address the outcome, objectives and outputs of this Agreement	
	Natural Disaster Relief and Recovery Arrangements (NDRRA)	• Category B measure (eligible for funding), essential public asset betterment. Betterment, in relation to an asset, means the restoration or replacement of the asset to a more disaster-resilient standard than its pre-disaster standard. Betterment of an asset will be considered an eligible measure if: a) the asset is an essential public asset; b) the state informs the Secretary of its decision to restore the asset to a more disaster-resilient standard, and of its reasons for doing so; c) the Secretary is satisfied with the cost effectiveness of the proposal; d) the Secretary is satisfied that the increased disaster-resilience of the asset will mitigate the impact of future natural disasters. • General principle to be observed by state with regard to eligible measures: its assistance is not to supplant, or operate as a disincentive for, self-help by way of either insurance or	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		appropriate strategies of disaster mitigation	
	National Emergency Risk Assessment Guidelines 2010	Climate change mentioned once (section 6.2.4, p.37)	
	National Principles for Disaster Recovery	• Notion of betterment included although not stated specifically: Recovery can provide an opportunity to improve these aspects beyond previous conditions, by enhancing social and natural environments, infrastructure and economies – contributing to a more resilient economy. 6 Principles: • Understanding the context – appreciate risks faced by communities, support those most vulnerable • Recognising complexity • Using community-led approaches • Ensuring coordination of all activities – be part of an EM approach that integrates with response and contributes to future prevention and preparedness • Employing effective communication • Acknowledging and building capacity – support the development of self-reliance, develop networks and partnerships to strengthen capacity	
	Australian Government Disaster Recovery Arrangements		
	Australian Emergency Management Arrangements		
	Climate Change Adaptation Action Plan	• Development of a nationally integrated and consistent approach to the implementation of climate change adaptation strategies	• Development of a National Statement on Climate Change Adaptation and EM • Provision of an internet website or hub hosting climate change and EM information, the National Climate Change and EM Information Portal • Development of Accreditation Scheme for Climate Change and/or Risk Management Practitioners

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		• Increase understanding of climate change science and its application to emergency management	• Host a National Climate Change and EM Roundtable for Government and Researchers • Produce an Annual Report on EM and Climate Change Projects to ensure information and data collected under EM grants programs is available • Development of Guide to Regional Climate Change Impacts for EM Decision Makers
		• *Working towards integration of climate change adaptation principles as they apply to the emergency management sector in settlement, land use planning and development decisions at the local level*	• *Work with PIA, DCC and UQ to incorporate consideration of climate change adaptation and EM as a consistent theme in professional development training modules for land use planners, both at Certified Practicing Planner level and for other planning professionals* • *At the jurisdictional/local level: Jurisdictional emergency managers to develop regular consultation mechanisms with local planning authorities to assist planners understand EM issues and requirements with regard to climate change adaptations* • *Develop National Guide to Climate Change and EM in Land Use Planning to ensure the consideration of the disaster risk implications of climate change in the development of future policies, codes and standards to do with the built environment and land use planning*
STATE	Queensland Disaster Management Act 2003		
	State Disaster Management Plan 2011	Only mention of climate change is in the foreword and in section 4.3.1.1 when describing the Natural Disaster Resilience Program which considers climate change. • Supplementary principles; a risk management approach to managing disasters; effective planning; a scalable, flexible structure; continuous improvement; coordination, collaboration and consultation; information management and communication; timely activation and pre-emptive operations; and use of appropriate legislation. • State Risk Register • Mitigation measures may be long term and should be built into corporate plans of local government and State agencies	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		• Community education and awareness – promoting public self-reliance through personal responsibility for managing risks as much as possible. • NDRRA guidelines – standard assistance: NDRRA Determination 2007 introduced a Betterment clause to enable post-disaster upgrading of essential public assets to a more resilient standard where it is determined to be cost-effective to do so. • NDRRA guidelines – special assistance: Category C known as the Community Recovery Package is designed to provide assistance to enable a more holistic recovery of a community severely affected by an eligible disaster event. [Note: Betterment notion does not seem to be included in the Recovery Section nor within recovery principles]	
	Disaster Management Strategic Policy Framework 2010	• Disaster Research Policy objective: use collaborative and best practice research to inform DM and improve the effectiveness of DM principles, policy development and practices • *Policy and Governance Policy Objective: DM outcomes are achieved through development and implementation of sound policy, practice and effective corporate governance* • Disaster Risk Assessment Policy Objective: Disaster risk assessments are used to identify and reduce vulnerability and improve preparedness and resilience to protect life and property and contribute to sustainable communities • Disaster Mitigation Policy Objective: Reduced risk and vulnerability through disaster mitigation/climate change adaptation initiatives to enhance community resilience and sustainability • Disaster Preparedness Policy Objective: Ensure prepared and disaster resilient individuals, communities, businesses and industries. Build capability and involvement of agencies, partners and stakeholders • Disaster Relief and Recovery Policy Objective: Sustainable reconstruction of physical infrastructure affected by a disaster. Sustainable restoration of the economy and the environment affected by a disaster.	• *Policy and Governance Policy Objective – Strategy: Integrate effective DRR initiatives into strategic and corporate plans at all levels of government, industry and commerce.* • Disaster Risk Assessment Policy Objective – Strategy: Include the impact of climate change on disaster risk assessment • *Disaster Mitigation Policy Objective – Strategy: Mainstream disaster mitigation into development planning, built environment/infrastructure design and DM practice* • *Disaster Mitigation Policy Objective – Strategy: Incorporate disaster mitigation into business continuity and corporate planning at all levels* • *Disaster Mitigation Policy Objective – Strategy: government agencies consider and design for the impacts of disasters and climate change adaptation where appropriate in the design and construction of public buildings and infrastructure* • Disaster Mitigation Policy Objective – Strategy: Share knowledge and innovative solutions to build community resilience and self-reliance • Disaster Preparedness Policy Objective – Strategy: Drive behavioural and social change through targeted community disaster resilience and preparedness education and awareness activities; Enhance community volunteer capability • Disaster Relief and Recovery Policy Objective – Strategy: Ensure the preparation of State, District and Local recovery plans addressing immediate, medium and long term recovery needs.

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
			• Disaster Relief and Recovery Policy Objective – Strategy: 'Betterment' – strengthen the connection between mitigation and recovery so that the same disaster event consequence is mitigated in future
	State Planning Policy 1.03 *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*	• Purpose of policy: This SPP sets out the State's interest in ensuring that the natural hazards of flood, bushfire, and landslide1 are adequately considered when making decisions about development. • SPP addresses development that has the potential to increase the extent or severity of natural hazards, but this aspect of the SPP applies only when planning schemes are being made or amended. Policy Outcomes • 1. Within natural hazard management areas, development to which this SPP applies is compatible with the nature of the natural hazard, except where: i) the development proposal is a development commitment; or ii) there is an overriding need for the development in the public interest and no other site is suitable and reasonably available for the proposal. • 2. Development that is not compatible with the nature of the natural hazard but is otherwise consistent with Outcome 1: i) minimises as far as practicable the adverse impacts from natural hazards; and ii) does not result in an unacceptable risk18 to people or property. • 3. Wherever practicable, community infrastructure to which this SPP applies is located and designed to function effectively during and immediately after natural hazard events commensurate with a specified level of risk. • 4. Natural hazard management areas are identified in the planning scheme. • 5. The planning scheme contains planning strategies that aim to: i) ensure that development in natural hazard management areas is compatible with the nature of the natural hazard; ii) minimise the impacts from natural hazards on existing developed areas; and iii) prevent development from materially increasing the extent or the severity of natural hazards.	
	Queensland Local Disaster Management	• Climate change mentioned twice: in Section 8.8.1 Community Context and section 8.8.2 Risk Identification [Section 8.8	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
	– Interim Guidelines	Disaster Risk Assessment] • Section 8.13.3 states that "recovery can also present the opportunity to further develop capability and resilience for the community through incorporating mitigation measures in the form of reconstruction efforts, risk reduction strategies or hardening of infrastructure and the built environment." Maybe 'betterment' notion should be included in this/articulated specifically.	
	Queensland Recovery Guidelines	Not yet available	
	2008 State Community Recovery Plan	Climate change only mentioned in State Risk Profile section	
	Queensland Evacuation Guidelines – for Disaster Management Groups	Only mention of climate change is in preliminaries section, Acknowledgements	
	Queensland Coastal Plan, including the State Planning Policy for Coastal Protection	<u>State Planning Policy for Coastal Protection</u> • 1. Land Use Planning • 2. Coastal Hazards – 2.1 Defining coastal hazard areas; 2.2 Where development may occur in coastal hazard areas; 2.3 Development in an erosion prone area; 2.4 Coastal protection work; 2.5 Development in high and medium coastal hazard areas • 6. Coastal-dependent development • 7. Canals and artificial waterways <u>State Policy for Coastal Management</u> • 2. Buildings and structures in erosion prone areas • 7. Buildings and structures on state coastal land • 9. Management Planning	<u>State Planning Policy for Coastal Protection</u> 1.1 Urban development to be consolidated by favouring infill and redevelopment of existing urban localities and minimising extent of the development footprint in coastal zone and avoiding the exposure of communities to the impacts of coastal hazards 1.2 Urban development is to follow a nodal settlement pattern and avoids creating or extending settlements in a ribbon or linear pattern along the coast unless, for a particular area, such a pattern is necessary due to landform constraints and/or the efficient provision of infrastructure. 1.3 Planning instruments are to show high and medium coastal hazard areas as a constraint on future development. 1.6 Local planning instruments are to incorporate a coastal hazard adaptation strategy (adaptation strategy) for urban localities that are projected to be within a high coastal hazard area between the commencement of the SPP and the year 2100. The adaptation strategy is based on an assessment of the mitigation options that will mitigate the hazard, including retreat, avoidance, and defence and a cost-benefit analysis to determine the most cost effective works or actions, taking into account long-term social, financial and environmental factors. 1.7 The adaptation strategy is to describe the:

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
			a) mitigation works or actions to be undertaken to mitigate the coastal hazard b) cost of undertaking the works or actions c) funding scheme or arrangements that will be established to pay for the works or actions to be completed d) timeline for the commencement and completion of the mitigation works or actions. 1.8 The adaptation strategy is to be incorporated into a local planning instrument for the relevant high coastal hazard area.
	SEQ Regional Plan 2009-2031	• DRO 1. Sustainability and climate change – 1.4 Natural hazards and climate change, Principle: Increase the resilience of communities, development, essential infrastructure, natural environments and economic sectors to natural hazards including the projected effects of CC • DRO 2. Natural Environment – 2.4 Managing the coast	• 1.4.1 Reduce the risk from natural hazards, including the projected effects of CC, by avoiding areas with high exposure and establishing adaptation strategies to minimise vulnerability to riverine flooding, storm tide or SLR inundation, coastal erosion, bushfires and landslides • 1.4.2. Reduce the risk from natural hazards, including the projected effects of CC, by establishing adaptation strategies to minimise vulnerability to heatwaves and high temperatures, reduced and more variable rainfall, cyclones and severe winds, and severe storms and hail • 1.4.3 Planning schemes and development decisions shall be in accordance with the Qld Coastal Plan, incl. The range of potential SLR • 1.4.4 Align and coordinate the implementation of regional policies to increase resilience to and reduce risks from natural hazards, incl. Projected effects of CC, through the SEQ CC Management Plan • 1.4.5 Develop performance criteria for the planning and design of development and infrastructure to manage risks from natural hazards and CC. • 2.4.2 Ensure development other than maritime infrastructure avoids erosion prone areas, storm tide inundation hazard areas, and undeveloped sections of tidal waterways in accordance with the Qld Coastal Plan
	SEQ Natural Resource Management Plan 2009-2031		
	Climate Q: Towards a greener Queensland	• Activities already underway: Cyclone preparedness workshops delivered annually in communities at risk; Development of	• Disaster Preparedness in Vulnerable Communities Program: Community resilience by integrating community education into

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
	2009	recruitment and retention initiatives under the DCS's Volunteer Management Strategy, and planning processes with local government to quantify local SES requirements into the future; A review of Queensland's heatwave strategy. • Improved mapping for climate change responses • Support our Heroes Program/Initiative – strengthening of SES and Rural Fire Service ($13million over 5 years) • Disaster Preparedness in Vulnerable Communities Program – 5 year $6.93million to develop community awareness and improve individual, household and business capacity • Bushfire Community Training Package - $4.6million program over 5 years to develop and support a network of Volunteer Community Educators to deliver bushfire and natural disaster community education • Disaster Management warehouses and caches – warehouse established in SEQ to store stockpiles of emergency equipment • Keeping our mob ClimateSafe - $2million funding over 3-year period • Improved fire management in national parks	disaster management; Business continuity planning in response to climate change; Property resilience through practical steps that homeowners can take to better protect their homes from the impacts of cyclones and storms; Mass evacuation planning across Queensland
	ClimateSmart Adaptation 2007-2012	• 30. Contribute to the development of a Queensland Local Government Climate Change Management Strategy. • 31. Incorporate changes in flood risk due to climate change in the proposed State Flood Risk Management Policy, local government floodplain management plans and relevant state guidelines. • 34. Periodically review physical infrastructure to determine: the extent to which climate change may affect operational performance; whether measures are needed to ensure system durability, safety and reliability. • 35. Review the effectiveness of existing planning tools in addressing the increased risks from climate change, including the: State Planning Policy 1/03; State Coastal Management Plan; local government planning schemes • 36. Review planning guidance given to local government on shoreline erosion management to ensure it integrates climate change, and establish an associated grants scheme. • 42. Incorporate the latest technical information, such as the Australian Rainfall and Runoff Data, in risk assessment prior to designing and planning roads, bridges and other transport infrastructure subjected to flood and heat stress.	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		• 51. Build the capacity of disadvantaged communities to effectively respond to the potential social and economic impacts of climate change. • 52. Continue to provide planning and emergency management advice on storm tides, and investigate whether measures are adequate for the next 30 years. • 53. Ensure that reviews of local disaster management plans include relevant climate change issues. • 54. Implement actions from the 2006 Cyclone Summit, namely: provide extra funding to help local councils rebuild after natural disasters • 55. Extend 'preparedness and awareness' programs to communities where the risk of extreme climatic events has increased. • 56. Review the *Queensland Heatwave Response Strategy* to ensure it appropriately considers climate change.	
	Draft SEQ Climate Change Management Plan	• Draft Action 21. Update the current guideline, M*itigating the adverse impacts of storm tide inundation* to incorporate current climate change science • Draft Action 22. Implement the policies of the new Qld Coastal Plan through regional and local planning and development and infrastructure decision making in SEQ • Draft Action 23. Acquire fine-scale digital elevation data for coastal areas for use in assessing risk and mapping hazard-prone areas in SEQ • Draft Action 24. Prepare and publish regional and local-scale risk assessments and maps of coastal hazard-prone areas using the methodology, SLR and storm-intensity factors in the new Qld Coastal Plan • Draft Action 25. Review and update *SPP 1/03* and develop supporting guidelines • Draft Action 26. Develop guidelines for the preparation of hazard and risk maps including the projected effects of CC on natural hazards within the scope of the revised SPP 1/03 • Draft Action 27. Develop a regional summary of projected CC impacts for SEQ • Draft Action 28. Prepare local-scale climate-resilient urban planning and design guidelines and performance criteria for sensitive areas	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		• Draft Action 31. Facilitate the uptake of research knowledge about CC adaptation by SEQ local governments and state agencies. • Draft Action 32. Develop and implement a communications strategy to support actions to build resilience to natural hazards and the projected effects of CC in SEQ	
LOCAL	Local Disaster Management Plan – Sunshine Coast		
	LDMP – Gold Coast		
	LDMP – Moreton Bay		
	LDMP – Ipswich City		
	Local Community Recovery Plan – Ipswich City	• Scope of plan is medium to long term flood recovery actions • Human, Social and Economic Recovery Committee's role is to develop a medium to long term plan to manage local disaster recovery • Human, Social and Economic Recovery Actions – Strategy 3; Employment/job skills development office; Strategy 6. Community preparedness and resilience; Strategy 7 Research, Planning and Engagement • Forward Planning Actions – Strategy 1 Management of development in flood prone areas (Action 1.2 Planning Scheme Amendment; Action 1.3 Planning Scheme Review) • Environmental Recovery Actions – Strategy 2 Construction; Strategy 5 Preparedness and resilience; Strategy 6 Research and Planning • *Infrastructure Recovery Actions – Strategy 1 Public Assets*	• Human, Social and Economic Recovery Actions Strategy 3 – Action 3.1 Promote economic support services to business owners and employees; Action 3.2 Mitigate impacts of the floods on the Local and District Supply Chain; Action 3.5 Support development and maintenance of labour force capacity and capability through employment and training options and other support • Human, Social and Economic Recovery Actions Strategy 6 – Action 6.1 Community review of the flood experience; Action 6.2 Targeted education around high risk areas (several sub-actions of interest); Action 6.6 Local Resilience Building Projects • Human, Social and Economic Recovery Actions Strategy 7 – Action 7.1 Creating a good evidence base • Environmental recovery actions – Strategy 2 Action 2.6 Ensure flood risk reduction is considered in planning of rebuilding and reconstruction • *Environmental recovery actions – Strategy 5 Action 5.1 Take steps to significantly increase preparedness and resilience in the Ipswich community in regard to public health risks during disaster* • *Environmental recovery actions – Strategy 6 Action 6.1 Use research to establish an evidence base of public health and environmental issues related to the 2011 flood event [includes climate change and adaptation: Consideration of flood related*

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
			matters in the climate change risk assessment and development of an adaptation response plan]; Action 6.2 Use established evidence base to inform disaster planning • *Infrastructure Recovery Actions – Strategy 1 Action 1.2 Consider flood risk reduction in the design of reinstated assets where possible*
	Gold Coast Climate Change Strategy 2009-2014	• Strategic Outcome 1: Council is a leader in localised action to address global CC challenges and opportunities • Strategic Outcome 3: Council's response is informed by sound research, specific to the GC • Strategic Outcome 5. Council and community response to CC is enabled by improved awareness and understanding • Strategic Outcome 6: the city's infrastructure is resilient to the impacts of CC • Strategic Outcome 7: Council has a planned CC response that meets its statutory responsibilities	• 20. Undertake a planning study to determine the CC considerations that will inform the Planning Scheme Review; • 21. Identify and map the GC environments most at risk from the impacts of CC; • 22. Having regard to emerging science, analyse the potential risks to the city posed by a range of future CC scenarios incl. SLR parameters occurring at a more rapid rate than anticipated • 24. Establish information sharing and collaborative partnerships with community service providers to manage the risks of CC for the city • 26. Develop an internal training and awareness campaign for Council staff to increase understanding and awareness of climate change risk mitigation and adaptation and its application to decision making processes • 34. Incorporate CC considerations in the review of Council's Integrated Transport Plan • 35. Apply Council's established CC parameters to develop and implement a shorelines Management Plan to mitigate and adapt to CC risks
	Gold Coast City Council Corporate Plan 2009-2014	• Key focus area 1 – A city leading by example: informed and engaged citizens; resilient, adaptive and maximising opportunities presented by emerging challenges such as CC; 1.4 respond to current and emerging challenges by working together • 2.4 the city's beaches and coastline are protected to sustain their amenity and biodiversity • 2.5 water and waterways across the city are protected and enhanced • 4.2 We are a safe and secure community and people live and visit without fear • Key Focus area 6 – A city shaped by clever design; 6.1 Integrated land use planning takes account of environmental, social and economic needs to provide the basis for a	• 1.1.4 Encourage and promote innovative design, building practice and land use to support sustainable building practices within the city • 1.2.2 Encourage community participation through local groups, not-for-profit organisations and volunteering activities • 1.4.3 Encourage the community to actively engage in planning for and responding to city challenges • 2.3.3 Plan and manage the city's conservation network to protect the city's biodiversity and help mitigate the risks of CC • 2.4.4 Ensure that beaches, marine and estuarine ecosystems can adapt to the impact of CC • 2.4.5 Prepare and protect coastal beaches from the impact of storm activity • 2.5.5 Improve waterway resilience to increase recovery

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		sustainable community.	potential from the impact of floods and storm surges • 4.2.8 Maximise disaster management response in the city by implementing and regularly testing the disaster management plan and responding to disaster events such as floods, storm surges and wildfire • 4.2.9 Provide effective welfare programs which support the local community in the event of emergencies or disasters • 6.1 Develop and implement a new Planning Scheme by 2012 that integrates the city's vision into Council decision-making; encourages sustainable development and takes account of the impact on our unique Gold Coast landscape, coastline and beaches • 6.4.3 undertake master planning to ensure development in activity centres and major urban growth areas reflects SEQ's subtropical climate and local character; provides design excellence and can adapt to a changing climate
	Gold Coast Shoreline Management Plan	•	
	Moreton Bay Climate Change Policy	• Council to take reasonable, measured and developing steps to incorporate into its operations a planned approach to dealing with CC • Evaluating CC implications for significant capital and operational activity, operational decision making and setting of policy positions; risk management through appropriate mitigation and adaptation strategies • Council will plan to reduce vulnerability to weather related risk, continue to improve response through mitigation and adaptation measures • Four themes: governance, infrastructure, planning and regulation, advocacy and awareness	
	Moreton Bay Sustainability Policy	No mention of climate change	
	Moreton Bay Regional Council Corporate Plan 2009-2014	• Outcome – Safe and harmonious communities with high public health standards; Lead and coordinate well-planned responses to community emergencies; • Outcome – Sustainable management and protection of the natural environment; Undertake activities that respond to CC, reduce pollution and GH emissions and promote energy	

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
		efficiency • Outcome – Strong leadership and governance that upholds corporate values and builds trust within the community; Develop partnerships and engage with local communities and stakeholders • Appendix 1 Local and regional issues – Disaster Management: implementation of PPRR; recognise need to coordinate DM activities and efforts across regions and surrounding areas; membership with SEQ DM Advisory Group (SEQDMAG); key hazards include global SLR and effects of CC which may increase risk of localised flooding and storm surge • Appendix 1 Local and regional issues – Environmental management: Effects of CC, including global SLR and associated impacts on natural habitats and ecosystems; development of mitigation and adaptation strategies for the region in response to CC • Appendix 1 – Infrastructure provision, maintenance, restoration or replacement: SLR and changing weather patterns causing increased maintenance and replacement costs • Appendix 1 – Community development and human services: unconnected and poorly serviced communities; vital role of volunteering in community	
	Sunshine Coast Climate Change and Peak Oil Strategy 2010-2020	• Objective 1: Council to provide leadership and demonstrate best practice – 100 year planning horizon; mainstream CC and energy transition into decision making; adopt robust reporting, monitoring and measuring; demonstrate 'duty of care' • Obj, 2: Build capacity for Council and community through partnership and advocacy – engage and empower the community; lead through partnership and advocacy • Objective 5: Identify and plan for climate change risks – Identify regional risks and vulnerabilities from CC; Reduce CC risks through effective land use planning; Incorporate CC into disaster planning and health; Incorporate CC into coastal management • Objective 6: Adapt to the impacts of CC: strengthen resilience of natural landscape; reduce risk to council assets and infrastructure; promote opportunities	• 1.1 Endorse 100 year planning horizon • 1.3 Progressively integrate CC and peak oil implications into Council's strategies, policies and plans • 1.9 Inform community of CC and peak oil impacts and risks • 1.10 Provide appropriate advice to Council customers regarding CC risks and vulnerability posed to property or assets (new and existing) particularly in relation to property searches, flood certificates and similar requests for information • 1.11 Hold discussions with insurance companies in order to determine changes in insurance coverage due to CC and, where relevant, generate appropriate awareness and responses • 2.4 Develop and implement information, training and communication programs to build the capacity of community, industry and business. • 5.1 Undertake initial vulnerability and hazard mapping to identify major risk areas due to CC on Sunshine Coast • 5.2 Incorporate CC into all hydrological mapping and

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
			forecasting • 5.3 Complete CC risk assessments • 5.4 Adjust land use planning approaches to avoid new urban development in major CC risk areas, etc. • 5.5 Long-term disaster response planning to consider CC risks with particular attention to vulnerable communities including visitors • 5.6 Provide community safety programs that factor in CC • 5.9 Develop a coastal management strategy with shoreline erosion management plans where appropriate
	Sunshine Coast Waterways and Coastal Management Strategy		
	Sunshine Coast Social Infrastructure Strategy 2011	•	•
	Sunshine Coast Corporate Plan 2009-2014	• 2. Ecological sustainability – 2.1 The impact of climate change; 2.4 healthy waterways and foreshores; 2.6 Environmentally friendly infrastructure and urban design • 3. Innovation and creativity; 3.4 Council's working culture is dynamic, flexible and entrepreneurial • 4. Health and well-being – 4.1 Safe and healthy communities • 7. Managing growth – 7.1 The areas for growth and renewal are clearly defined • 8. Great governance – 8.5 Advocacy and partnerships; 8.6 An informed and engaged community	• 2.1.1 Research and understand the impact of climate change on council's operations and the region's environment and communities • 2.1.2 Develop and implement adaptive action plans to respond to CC • 2.4.1 Develop and implement a coastal management strategy • 2.6.1 Ensure new developments meet high standards of ecological sustainability and urban design • 3.4.3 Establish an innovation and sustainability unit to identify and coordinate new council economic and environmental initiatives • 4.1.4 Maintain and develop council's emergency and disaster management planning, prevention, response and recovery capabilities • 7.1.3 Ensure new communities are developed using Ecologically Sustainable Development principles • 8.5.1 Establish strong partnerships with all levels of government and create alliances with peak bodies and the community • 8.6.1 Develop a community plan that sets long term directions and aspirations for the future of the region • 8.6.2 Establish a community engagement framework to gather

Level	Instrument	Principles, Policies, Programs and/or Actions	Detailed Projects, Outcomes
			community feedback, build relationships and allow input into council decision making
	Ipswich 2020 and Beyond – Vision Statement and Action Plan Framework		
	Ipswich City Council Corporate Plan 2007-2012	• GM5.1 Implement Ecologically Sustainable Development and climate responsive design principles in the design and construction of new buildings • CSW 2 – Participation and community capacity • CSW 6 – A safe community; CSW6.3 Ipswich is to have the benefits of well-equipped, well-staffed essential and emergency services including both professional staff and volunteers • IS2.2 Ipswich residents have access to a range of quality health and emergency services in accordance with community expectations and national and international standards	

Legend: _ Emergency Management related/relevant actions in non-emergency management policies, programs or plans
_ *Cross-sectoral actions in emergency management policies, programs or plans*

APPENDIX C: CLIMATE CHANGE ADAPTATION OPTIONS APPRAISAL CRITERIA

(Human Settlements Component)

Criterion	High [1]	Low[1]
Flexibility	A flexible measure is one that: turn on/off; is responsive and flexible to changing future conditions; and is adaptable and can be implemented with flexibility.	Is the opposite of high (locks you in with no/little choice and future options). Option is not responsive and flexible to changing future conditions.
Robustness	Is able to operate efficiently and effectively across a wide range of variables/uncertainties. Not very risky.	Can only cope well with a specific or limited set of variables or uncertainties; is highly sensitive to future changes. Risky.
Equity	Option has minimal negative impacts on other communities/regions/states. Option improves current situation/inequity.	Option has significant negative impacts on other communities/regions/states. Option does not contribute to improving current situation/inequity.
Coherence/alignment (synergy) - alignment	Consistent / aligned with other strategic objectives, measures, policy goals and sectors. Synergistic (e.g. ticks > 1 business objective)	Has negative impact or conflicts with other strategic objectives, measures, policy goals and sectors.
Coherence/alignment (synergy) - enhancement	Option that builds on or enhances the expected outcomes from existing policies/initiatives in place before the introduction of the climate change adaptation option	Option that leads to a decline in the expected outcomes of existing policies/initiatives in place before the introduction of the climate change adaptation option
Acceptability: i) Political acceptability ii) Community acceptability iii) Bureaucratic acceptability iv) Private sector acceptability	Option is stakeholder (includes politicians, decision makers, communities, private sector) focused and provides solutions that are acceptable to wide range of stakeholders. High acceptability: acceptable to > 2 different groups of stakeholders	Option is not acceptable to a wide range of stakeholders (includes politicians, decision makers, communities, private sector) and is likely to conflict with some stakeholders. Low acceptability: acceptable to <2 different groups of stakeholders

Criterion	High [1]	Low[1]
Avoidance of maladaptation – Low GHG emissions	Option does not increase GHG emissions.	Option increases GHG emissions.
Avoidance of maladaptation – Less Vulnerable populations	Option does not disproportionately burden vulnerable populations.	Option disproportionately burdens vulnerable populations.
Avoidance of maladaptation – Low Opportunity Costs	Option results in low or no opportunity costs (social, environmental and economic costs lower than alternative).	Option results in high opportunity costs (social, environmental and economic costs higher than alternative).
Avoidance of maladaptation – Adaptation Incentives	Option does not reduce incentives to adapt (planned and autonomous adaptation).	Option reduces incentives to adapt (planned and autonomous adaptation).
Avoidance of maladaptation – Low Path Dependency	Option does not result in path dependency, i.e. actions that do not limit choices available to future generations.	Option results in path dependency, i.e. actions that limit choices available to future generations.
Legend: [1] "high" being favourable and "low" being unfavourable. So for example: **Coherence/**alignment – an option that aligns strongly with other policies/objectives would gain a "high" against this criteria; and **Equity** – an option that has potential negative spill-over effects onto other communities/regions/states would be marked "low" against equity.		

APPENDIX D: HUMAN SETTLEMENTS ADAPTATION OPTIONS

URBAN PLANNING & MANAGEMENT

D1: Urban Planning and Management Adaptation Options

(refer to Section 1 of the Supplementary Report for a full description of Policies, Program, Action and Implementation recommendations)

Overarching Goal: Establish adaptation strategies within statutory and non-statutory planning processes to minimise the region's vulnerability and risks from climate change impacts, including the changing nature and/or intensification of natural hazards.

Key words: urban planning and management, coastal landscapes, inland landscapes, adaptive capacity

Policy 1. The statutory and non-statutory planning processes must seek to minimise the vulnerability of coastal landscapes to storm tide and sea level rise inundation, coastal erosion, cyclones and severe winds, severe storms and hail, and flooding.

Program 1.1 Consolidation of urban development: Urban development is consolidated by favouring infill and redevelopment of existing urban areas to minimise the extent of development occurring in highly vulnerable coastal areas.
Program 1.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.
Program 1.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to coastal hazards.
Program 1.4 Building code design criteria: Building codes are reviewed to incorporate design criteria for buildings to resist future loads that may result from the impact of climate change-exacerbated hazards during a minimum service life of 50 years.
Program 1.5 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to reduce or eliminate damage caused by flooding as a result of sea level rise and coastal storm surge events.
Program 1.6 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to receding shorelines are sited landward and/ or relocated.
Program 1.7 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure.
Program 1.8 Coastal defence: Coastal defence mechanisms are implemented to provide continuing flood and erosion risk management due to storm tides and sea level rise.
Program 1.9 Hazards full disclosure clause: A Coastal Hazards Full Disclosure Law is implemented to alert buyers of coastal properties about current and future climate related risks such as erosion rates, storm history, inundation and sea level rise.

Program 1.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/or equipped with back-up systems.

Program 1.11 Innovative design for coastal areas: Innovative engineering and design solutions are employed to manage coastal hazards in low risk areas.
Program 1.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.
Program 1.13 Protection of coastal habitats: Areas that provide for the landward retreat of coastal habitats and species at risk from predicted sea level rise are identified and protected.
Program 1.14 Long-term (strategic) planning: Planning and decision-making consider the potential implications of climate change over the life of long-term assets (100 year planning horizon).

Program 1.15 Coordinated response to sea level rise: A coordinated response to sea-level rise is initiated to develop measures related to coastal defence, accommodation and planned retreat.
Program 1.16 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.

Program 1.17 Coastal erosion risk minimisation: A coastal erosion preparedness and awareness scheme is initiated to minimise risks from coastal erosion, including climate change projections, in vulnerable areas.
Program 1.18 Coastal inundation risk minimisation: A coastal inundation preparedness and awareness scheme is initiated to minimise coastal inundation risks, including climate change projections, in vulnerable areas.
Program 1.19 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Policy 2. The statutory and non-statutory planning processes must seek to minimise the vulnerability of inland landscapes to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.

Program 2.1 Consolidation of urban development: Infill development is consolidated in existing urban areas while avoiding areas with high exposure to flooding and bushfire.
Program 2.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.
Program 2.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to climate change impacts.
Program 2.4 Building code design criteria for floods: Building codes are reviewed to ensure building structures withstand projected site-specific flood levels.
Program 2.5 Building code design criteria for bushfire: Building codes are reviewed to ensure building structures are more resilient to bushfires.
Program 2.6 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to improve adaptation to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.
Program 2.7 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to floodplains are sited landward and/ or relocated.
Program 2.8 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure.
Program 2.9 Hazards full disclosure clause: A Hazards Full Disclosure Law is implemented to alert buyers of properties about current and future climate related risks associated with flooding, including riverine and flash floods, and bushfire.

Program 2.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/ or equipped with back-up systems.

Program 2.11 Innovative designs for floods: Innovative engineering and design solutions are employed to minimise vulnerability to flooding in low risk areas.
Program 2.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.
Program 2.13 Mapping of flood vulnerable areas: A program is created to map and catalogue developed building sites that are flooded three or more times over a 10 year-period.

Program 2.14 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.

Program 2.15 Flood risk minimisation: A flood preparedness and awareness scheme is initiated to minimise both flash flood and riverine flood risks, including climate change projections, in flood prone areas.
Program 2.16 Bushfire risk minimisation: A bushfire preparedness and awareness scheme is initiated to minimise bushfire risks, including climate change projections, in bushfire prone areas.
Program 2.17 Heatwave risk minimisation: A heatwave preparedness and awareness scheme is initiated to minimise heatwave risks, including climate change projections, in heatwave prone areas.
Program 2.18 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Policy 3. SEQ's planning processes must have strong adaptive capacity to improve decision-making to adapt to climate change.

Program 3.1 Leadership development: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Program 3.2 Capacity building: Local governments' capacity must continue to be built through improved knowledge and skills about climate change.
Program 3.3 Risk communication on climate change: Communication of climate change risks to decision-makers and wider community (flooding, storm surge, heatwave and sea level rise) must be improved.

Program 3.4 Risk allocation mechanisms: Climate change risks must be incorporated into decision-making processes.

Program 3.5 Professional and sub-professional education and training: A mandatory training program is created to educate professionals and sub-professionals in relevant fields (e.g. planning, architecture, surveying, building certification, real estate agents, engineering, and construction management) on the need to incorporate adaptation to climate change and natural hazards as a basis for establishing design criteria for new infrastructure and housing estates.

Program 3.6 Anticipatory planning response: The vulnerability of existing settlements in SEQ to climate change-exacerbated hazards, including natural hazards must be reduced through pro-active action.

Statutory planning
Non-statutory planning
Non-statutory and/or statutory planning

Figure D1.1: Urban Planning and Management Adaptation Options Framework

Legend: Statutory planning | Non-statutory planning | Non-statutory and/or statutory planning

Policy 1. The statutory and non-statutory planning processes must seek to minimise the vulnerability of coastal landscapes to storm tide and sea level rise inundation, coastal erosion, cyclones and severe winds, severe storms and hail, and flooding.
Program 1.1 Consolidation of urban development: Urban development is consolidated by favouring infill and redevelopment of existing urban areas to minimise the extent of development occurring in highly vulnerable coastal areas. **Action 1.1.1:** Assess the vulnerability, socially and physically, to coastal hazards of areas designated to accommodate future population growth, including transit oriented developments (TODs). **Action 1.1.2:** Identify and monitor areas that require special protection and/or defence. **Action 1.1.3:** Establish special zoning and performance criteria for building structures located in areas at risk to withstand coastal hazards. **Action 1.1.4:** Define zones within new development that should have limited density and intensity determined by their level of risk and ensure structures are designed or retrofitted to be more resilient to flood impacts. **Action 1.1.5:** Identify areas for land use conversion that incorporate projected coastal hazards threats in the next 50 to 100 years. **Action 1.1.6:** Define developers' responsibilities in land use development of areas subject to coastal hazards in the next 50 to 100 years. (e.g. fee to cover the costs of potential emergency response, future armoring, to mitigate impacts to natural habitats from future armoring, or to improve flood resilience of infrastructure that services the new development (developer must design the new development and its supporting infrastructure to be more resilient to flood impacts. For example, permits could require that roads be elevated and that sewer lines be more resilient to floods.) **Action 1.1.7:** Define landowners' responsibilities in locations subject to coastal hazards in the next 50 to 100 years (e.g. landowner agrees to remove structures when they become inundated due to encroachment. As the seas rise, the boundary between private lands and public beaches (the tide line) will be pushed inland. This type of condition allows landowners to develop property but with the expectation that development will eventually have to cede to the rising seas; landowner dedicates an easement to preserve natural buffers, floodways, or to provide public access). **Action 1.1.8:** Ensure siting of essential public assets outside areas at risk and/ or in vulnerable areas with low risk of flooding whilst avoiding the isolation of communities. **Action 1.1.9:** Ensure essential infrastructure is decentralised and/or are equipped with redundancy and back-up systems. **Action 1.1.10:** Ensure infill and redevelopment of existing urban areas take into account the provision of evacuation routes and shelters to minimise the vulnerability of communities to coastal hazards, including storm tides, coastal inundation and flooding.
Program 1.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts. **Action 1.2.1:** Conduct inventory to identify the vulnerability of essential infrastructure sites and corridors to coastal hazards. **Action 1.2.2**: Define protection zones, i.e. areas with essential public assets that permit coastal armouring and/or being elevated. **Action 1.2.3:** Ensure proposed essential infrastructure sites and corridors are sited outside coastal risk areas.
Program 1.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding

community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to coastal hazards.

Action 1.3.1: Conduct an inventory in partnership with health and emergency management agencies to identify areas within the community that have a high concentration of vulnerable groups.
Action 1.3.2: Calculate and allocate funds to assist vulnerable groups to retrofit their residences to be more resilient to coastal hazards.
Action 1.3.3: Determine, based on inventory, as to whether localities require the establishment of shelters, including public cool spaces, to protect community from extreme weather events.
Action 1.3.4: Ensure new development provide adequate number of residential accommodation that caters for the needs of vulnerable groups, including the assessment of the need for shelters for extreme weather events.
Action 1.3.5: Ensure residents are familiar with evacuation procedures in case of extreme weather events.

Program 1.4 Building code design criteria: Building codes are reviewed to incorporate design criteria for buildings to resist future loads that may result from the impact of climate change-exacerbated hazards during a minimum service life of 50 years.

Action 1.4.1: Ensure all new and substantially renovated buildings (greater than 25% of the current replacement value of the structure) located along canals and waterways provide for setbacks from the waterway and have 500mm freeboard measurement above a projected site-specific flood level.
Action 1.4.2: Require special foundations that are more resilient to erosion and wave impacts and use of flood-resilient construction materials.
Action 1.4.3: Create an inspection services scheme for homeowners to help them identify ways in which they could retrofit their homes to make them more resilient to coastal hazards damage.

Program 1.5 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to reduce or eliminate damage caused by flooding as a result of sea level rise and coastal storm surge events.

Action 1.5.1: Conduct a comprehensive inventory to determine the physical number and nature of buildings (residential and commercial) threatened by coastal inundation due to rising sea levels and storm surge to estimate cost of retrofitting properties.
Action 1.5.2: Define areas that require priority actions, including retrofitting of properties at risk.
Action 1.5.3: Establish funding mechanisms to support retrofitting of properties and buy back schemes, e.g. federal and state government and private sector.
Action 1.5.4: Create household funding metrics based on households' vulnerability (e.g. high risk properties and socio-economic disadvantage).
Action 1.5.5: Create an inspection services scheme for homeowners in high risk areas to help them identify ways in which they could retrofit their homes to make them more resilient to coastal hazards.
Action 1.5.6: Create incentives/rebates packages to property owners for the retrofitting of properties threatened by coastal hazards and/or ear-marked for planned retreat.
Action 1.5.7: Provide financial assistance to local governments to retrofit homes that have been repetitively damaged by coastal hazards, demolish damaged homes, elevate essential public assets, and move essential public assets.
Action 1.5.8: Establish partnership with insurance companies to map properties at risk of coastal hazards and establish thresholds to guide insurance premiums.

Action 1.5.9: Identify barriers and opportunities for retrofitting program based on household tenure (e.g. rental properties, first home, second home).
Program 1.6 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to receding shorelines are sited landward and/ or relocated. **Action 1.6.1:** Assess the vulnerability of existing urban areas to rising sea levels and storm surges. **Action 1.6.2:** Establish a staging process to implement planned retreat of vulnerable areas whilst minimising adverse social impacts. **Action 1.6.3:** Investigate the effectiveness of different mechanisms to implement planned retreat, including land acquisition, voluntary by-back schemes, rolling easements, transfer of development rights, purchase of development rights, tighter rules for setbacks and/or tax incentives. **Action 1.6.4:** Limit or prohibit rebuilding of damaged structures in defined retreat areas. **Action 1.6.5:** Identify suitable areas to accommodate the relocation of coastal communities/population at risk whilst ensuring emergency and health services and facilities continue to be provided to communities/population at risk. **Action 1.6.6:** Establish an engagement and communication strategy to consult with coastal communities at risk. **Action 1.6.7:** Encourage land owners to relocate structures through tax benefits, voluntary land acquisitions, or conservation easements schemes. **Action 1.6.8:** Develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas. **Action 1.6.9:** Ensure the restoration and rehabilitation of areas post-retreat.
Program 1.7 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure. **Action 1.7.1:** Assess the vulnerability of essential emergency and health services to coastal hazards and conduct an inventory to determine which ones require upgrade and/or strategic relocation. **Action 1.7.2:** Calculate and allocate funds for relocation and upgrading of essential emergency and health services. **Action 1.7.3:** Establish a staging process to implement relocation and upgrade of essential emergency and health services. **Action 1.7.4:** Consult with communities to strategically relocate and/or upgrade essential emergency and health services to ensure communities do not become disadvantaged in the process. **Action 1.7.5:** Investigate feasibility of decentralisation of essential emergency and health services and facilities as a retreat option. **Action 1.7.6:** Ensure strategic relocation and upgrade of essential emergency and health services are aligned with strategies forecasted for transportation and communication systems.
Program 1.8 Coastal defence: Coastal defence mechanisms are implemented to provide continuing flood and erosion risk management due to storm tides and sea level rise. **Action 1.8.1:** Asses the vulnerability of existing urban areas to rising sea levels and storm surges. **Action 1.8.2:** Undertake comprehensive research and analysis to determine alternative solutions to defence mechanisms by assessing the engineering, economic, social and environmental aspects of whether or not selected sections of the coasts can or should be protected. **Action 1.8.3:** Identify and define protection zones, i.e. areas with dense urban development that permit coastal armouring.

Action 1.8.4: Investigate the feasibility of different mechanisms used to implement and manage coastal defence, including soft and/or hard armoring techniques.
Action 1.8.5: Allocate funding to enable the construction and management of coastal defence structures.
Action 1.8.6: Establish a staging process for the implementation of coastal defence structures to protect identified areas at risk.
Action 1.8.7: Conduct a review of legislative frameworks to identify and conduct necessary amendments to enable implementation of coastal defence mechanisms.

Program 1.9 Hazards full disclosure clause: A Coastal Hazards Full Disclosure Law is implemented to alert buyers of coastal properties about current and future climate related risks such as erosion rates, storm history, inundation and sea level rise.

Action 1.9.1: Establish State laws to require sellers of real estate to disclose information to coastal property buyers either before or at the point of contract about risks related to coastal hazards, such as location in a known inundation hazard area, current erosion rate, and/or setback and building restrictions.
Action 1.9.2: Ensure insurance companies adequately inform their customers about the risks climate change poses to the insurance business and the ability of the industry to pay policyholders' claims.
Action 1.9.3: Establish stronger rules for real estate disclosure to provide coastal property buyers information of the potential perils associated with developing or purchasing property seaward of the [state's] oceanfront setback line.
Action 1.9.4: Develop and update a coastal hazards website to provide information to the public and government, including maps and data.
Action 1.9.5: Conduct a review of legislative frameworks to identify and establish necessary amendments to enable enforcement of full hazards disclosure clause.
Action 1.9.6: Consult with community to improve communication about future climate related risks on private properties.

Program 1.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/or equipped with back-up systems.

Action 1.10.1: Assess the vulnerability of high priority services and buildings to coastal hazards and conduct an inventory to determine which ones require decentralisation and back-up.
Action 1.10.2: Calculate and allocate funds for construction and implementation of additional high priority services and buildings in low risk areas.
Action 1.10.3: Encourage the decentralisation of essential services and buildings.
Action 1.10.4: Encourage the establishment of back-up systems to provide spare capacity for essential services and buildings.
Action 1.10.5: Establish a staging process to implement decentralisation and back-up schemes for high priority services and buildings.
Action 1.10.6: Align the staging process for decentralisation and back-up schemes for high priority services and buildings with staging process for strategic relocation and upgrade of essential emergency and health services.
Action 1.10.7: Promote the establishment of decentralised and back-up systems of essential services and buildings in new developments.

Program 1.11 Innovative design for coastal areas: Innovative engineering and design solutions are employed to manage coastal hazards in low risk areas.

Action 1.11.1: Encourage residential structures is areas subject to coastal inundation to have the lowest habitable floor raised or above the highest flood level by 500 mm.
Action 1.11.2: Encourage built areas below the flood level of residential structures subject to coastal inundation to be designed to allow flood waters to exit (e.g. walls must be designed to break away in storm events without causing loss of structural integrity).
Action 1.11.3: Encourage buildings to be anchored to the foundation to prevent movement of the structure during coastal inundation events.
Action 1.11.4: Encourage residential structures subject to coastal inundation to have their mechanical, electrical, and plumbing devices elevated above flood level.
Action 1.11.5: Encourage buildings structures subject to coastal inundation to be designed to be more resilient to flooding by using special coatings and sealings to make the walls impermeable to floodwater.
Action 1.11.6: Encourage essential infrastructure subject to coastal inundation to be either elevated or built to be more resilient to floods.
Action 1.11.7: Encourage building structures and essential infrastructure in areas subjected to damaging coastal wave action to be built and/or elevated above the base flood elevation, including storm surges. Building structures and essential infrastructure must also be specially anchored to withstand wind and wave action.

Program 1.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.

Action 1.12.1: Investigate the feasibility of raising the height of land and existing development.
Action 1.12.2: Investigate the feasibility of constructing structures that float on the surface of the water, or may be floated occasionally during a flood, making them largely invulnerable to changing tides.
Action 1.12.3: Investigate the feasibility of constructing structures that are designed to withstand flooding or to retain storm water.
Action 1.12.4: Encourage the retention of living shorelines or wetlands to absorb flood, slow erosion and provide habitat.
Action 1.12.5: Ensure emergency and health services and facilities continue to be accessible and operational during and after extreme weather events.

Program 1.13 Protection of coastal habitats: Areas that provide for the landward retreat of coastal habitats and species at risk from predicted sea level rise are identified and protected.

Action 1.13.1: Improve knowledge and understanding of the vulnerability of ecosystems to climate change impacts.
Action 1.13.2: Integrate an agreed biodiversity mapping approach and conduct an inventory of priority conservation areas to be affected by climate change impacts.
Action 1.13.3: Increase ecosystem resilience by restoring tidal wetlands, living shoreline and related habitats, and establish habitat corridors.
Action 1.13.4: Maintain upland buffer areas around tidal wetlands.
Action 1.13.5: Manage sediment for marsh accretion and natural flood protection.
Action 1.13.6: Establish rolling easements regulations to prohibited private landowners to erect bulkheads and any other structures that interfere with naturally migrating shores.

Program 1.14 Long-term (strategic) planning: Planning and decision-making consider the potential implications of climate change over the life of long-term assets (100 year planning horizon).

Action 1.14.1: Develop a 'worst-case scenario' state-level planning document that establishes general policies and guidelines for identifying areas and infrastructure that may no longer be supported through public funds. **Action 1.14.2:** Discourage expenditure of public funds on infrastructure in areas highly vulnerable to climate change impacts, especially sea level rise and increased risk of flooding from intense rainfall events.
Program 1.15 Coordinated response to sea level rise: A coordinated response to sea-level rise is initiated to develop measures related to coastal defence, accommodation and planned retreat. **Action 1.15.1:** Encourage state and local governments to establish policies and funding to facilitate easements to (a) relocate developments further inland, (b) remove development as hazards encroach into developed areas, or (c) facilitate landward movement of coastal ecosystems subject to dislocation by sea level rise and other climate change impacts. **Action 1.15.2:** Encourage state government to establish an oceanfront setback line to restrict further urban development in areas at risk from sea level rise. **Action 1.15.3:** Encourage state and local governments (or private land trusts or non-profit organisations) to acquire undeveloped property at risk from sea level rise in order to conserve environmental assets, such as wetlands and beaches, provide upland migration corridors, preserve habitat, or provide flood buffers for existing development. **Action 1.15.4:** Encourage state and local governments to prioritize developed properties at risk of sea level rise by purchasing conservation easements in areas identified to have significant value for habitat conservation, natural buffers and/or floodplain restoration, or where ecosystems can migrate inland as the seas rise.
Program 1.16 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years. **Action 1.16.1:** Reduce pressure on systems or areas at risk of coastal hazards by restricting and discouraging further development. **Action 1.16.2:** Introduce multiple land use strategies that account for coastal hazards due to climate change impacts. This includes raised buildings with less critical functions (e.g. parking, parkland) at ground level in flood prone areas, natural conservation areas that double as flood management areas, etc. **Action 1.16.3:** Implement state legislation to afford protection from legal liability for local councils where they provide advice or make a decision in good faith relating to coastal planning and the impact of climate change.
Program 1.17 Coastal erosion risk minimisation: A coastal erosion preparedness and awareness scheme is initiated to minimise risks from coastal erosion, including climate change projections, in vulnerable areas. **Action 1.17.1:** Assess the vulnerability of existing and proposed new urban and peri-urban areas to coastal erosion, including climate change projections that could exacerbate coastal erosion risks. **Action 1.17.2:** Identify areas for special protection and priority action (e.g. retrofitting; relocation of structures; land use conversion). **Action 1.17.3:** Create an inspection services scheme for homeowners in coastal erosion prone areas to help them identify ways in which they could retrofit their homes to make them more resilient to coastal erosion. **Action 1.17.4:** Calculate and allocate funds to assist homeowners to retrofit their residences to be more resilient to coastal erosion.

Action 1.17.5: Investigate funding options for voluntary land acquisition programs of areas highly vulnerable to coastal erosion and already identified for land use conversion.
Action 1.17.6: Identify special zoning to trigger more stringent building codes and design standards for new and existing developments in areas highly vulnerable to coastal erosion.
Action 1.17.7: Encourage residents of areas highly vulnerable to coastal erosion to develop and maintain emergency plans, including evacuation procedures.
Action 1.17.8: Ensure emergency and health services and facilities located in areas highly vulnerable to coastal erosion continue to be operational during and after extreme weather events.

Program 1.18 Coastal inundation risk minimisation: A coastal inundation preparedness and awareness scheme is initiated to minimise coastal inundation risks, including climate change projections, in vulnerable areas.

Action 1.18.1: Assess the vulnerability of existing and proposed new urban areas to coastal inundation, including climate change projections that could exacerbate coastal inundation risks.
Action 1.18.2: Identify areas for special protection and priority action (e.g. retrofitting; relocation of structures; land use conversion).
Action 1.18.3: Create an inspection services scheme for homeowners in coastal inundation prone areas to help them identify ways in which they could retrofit their homes to make them more resilient to flooding.
Action 1.18.4: Calculate and allocate funds to assist homeowners to retrofit their residences to be more resilient to coastal inundation.
Action 1.18.5: Investigate funding options for voluntary land acquisition programs of areas highly vulnerable to coastal inundation and already identified for land use conversion.
Action 1.18.6: Identify special zoning to trigger more stringent building codes and design standards for new and existing developments in areas highly vulnerable to coastal inundation.
Action 1.18.7: Encourage residents of areas highly vulnerable to coastal inundation to develop and maintain emergency plans, including evacuation procedures.
Action 1.18.8: Ensure emergency and health services and facilities located in areas highly vulnerable to coastal inundation continue to be operational during and after extreme weather events.

Program 1.19 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Action 1.19.1: Enhance existing parklands and acquire new parkland where feasible to improve availability of green spaces and reduce risks from future urban heat island effects (UHIE).
Action 1.19.2: Develop and carry out urban forestry and tree planting programs, and tree protection bylaws to reduce UHIE and sun exposure.
Action 1.19.3: Provide appropriate space and design for recreational needs, including forms of productive recreation such as community gardening, city farms and farmers markets.
Action 1.19.4: Protect, enhance and restore the health and integrity of natural ecosystems such as urban forests and waterways.

Policy 2. The statutory and non-statutory planning processes must seek to minimise the vulnerability of inland landscapes to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.
Program 2.1 Consolidation of urban development: Infill development is consolidated in existing urban areas while avoiding areas with high exposure to flooding and bushfire. **Action 2.1.1:** Assess the vulnerability, socially and physically, to flooding and bushfire of areas designated to accommodate future population growth, including transit oriented developments (TODs). (NSW sea level rise policy) **Action 2.1.2:** Identify and monitor areas that require special protection, i.e. areas that have been flooded 3 or more times in the last 10 years, including retrofitting of properties at risk and implementation of buy back schemes of areas subject to recurrent flooding. **Action 2.1.3:** Establish special zoning and performance criteria to trigger more stringent building codes and design standards for building structures located in areas at risk from flooding and bushfire. **Action 2.1.4:** Define zones within new development that should have limited density and intensity determined by their level of risk and ensure structures are designed or retrofitted to be more resilient to flood impacts. **Action 2.1.5:** Identify areas for land use conversion that incorporate climate change projections likely to exacerbate the risk of floods and bushfires in the next 50 to 100 years. **Action 2.1.6:** Define developers' responsibilities in land use development of areas subject to flooding and bushfire in the next 50 to 100 years. (e.g. fee to cover the costs of potential emergency response or to improve flood resilience of infrastructure that services the new development. Developers must design the new development and its supporting infrastructure to be more resilient to flood impacts. For example, permits could require that roads be elevated and that sewer lines be more resilient to floods). **Action 2.1.7:** Define landowners' responsibilities in locations subject to flooding and bushfire in the next 50 to 100 years (e.g. landowner agrees to build and/or rebuild structures based on more stringent building codes and design standards, and have evacuation plans). **Action 2.1.8:** Ensure siting of essential public assets outside areas at risk and/ or in vulnerable areas with low risk of flooding whilst avoiding the isolation of communities. **Action 2.1.9:** Ensure essential infrastructure is decentralised and/or are equipped with redundancy and back-up systems. **Action 2.1.10:** Ensure infill and redevelopment of existing urban areas take into account the provision of evacuation routes and shelters to minimise the vulnerability of communities to flooding and bushfire.
Program 2.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts. **Action 2.2.1:** Conduct inventory to identify the vulnerability of essential infrastructure sites and corridors to flooding and bushfires. **Action 2.2.2:** Define protection zones, i.e. areas with essential infrastructure that permit elevation/retrofitting to withstand flooding, and retrofitting to withstand bushfires. **Action 2.2.3:** Ensure proposed essential infrastructure assets and corridors are sited outside risk areas and/ or in vulnerable areas with low risk of flooding and bushfire.

Program 2.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to climate change impacts.

Action 2.3.1: Conduct an inventory in partnership with health and emergency management agencies to identify areas within the community that have a high concentration of vulnerable groups.
Action 2.3.2: Calculate and allocate funds to assist vulnerable groups to retrofit their residences to be more resilient to climate change impacts, including flooding, bushfire and heatwaves.
Action 2.3.3: Determine, based on inventory, as to whether localities require the establishment of shelters, including public cool spaces, to protect community from extreme weather events.
Action 2.3.4: Ensure new development provide adequate number of residential accommodation that caters for the needs of vulnerable groups, including the assessment of the need for shelters for extreme weather events
Action 2.3.5: Ensure residents are familiar with evacuation procedures in case of extreme weather events.

Program 2.4 Building code design criteria for floods: Building codes are reviewed to ensure building structures withstand projected site-specific flood levels.

Action 2.4.1: Ensure all new and substantially renovated buildings (greater than 25% of the current replacement value of the structure) located along floodplains provide for setbacks from the waterway and have 500mm freeboard measurement above a projected site-specific flood level.
Action 2.4.2: Require special foundations that are more resilient to flood impacts and use of flood-resilient construction materials.
Action 2.4.3: Create an inspection services scheme for homeowners to help them identify ways in which they could retrofit their homes to make them more resilient to flooding.

Program 2.5 Building code design criteria for bushfire: Building codes are reviewed to ensure building structures are more resilient to bushfires.

Action 2.5.1: Ensure all new and substantially renovated buildings (greater than 25% of the current replacement value of the structure) located in bushfire prone areas provide for setbacks and buffers to be more resilient to bushfires.
Action 2.5.2: Ensure all new and substantially renovated buildings (greater than 25% of the current replacement value of the structure) located in bushfire prone areas utilise building material which are more fire retardant and/or resistant.
Action 2.5.3: Create an inspection services scheme for homeowners to help them identify ways in which they could retrofit their homes to make them more resilient to bushfire.

Program 2.6 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to improve adaptation to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.

Action 2.6.1: Conduct a comprehensive inventory to determine the number and nature of buildings and properties (residential or commercial) threatened by heatwaves and high temperatures, flooding, severe storms and hail, and bushfires to estimate cost of retrofitting properties.
Action 2.6.2: Define areas that require priority actions, including retrofitting of properties at risk.

Action 2.6.3: Establish funding mechanisms to support retrofitting of properties and buy back schemes, e.g. federal and state government and private sector.
Action 2.6.4: Create household funding metrics based on households' vulnerability (e.g. high risk properties and socio-economic disadvantage).
Action 2.6.5: Create an inspection services scheme for homeowners in high risk areas to help them identify ways in which they could retrofit their homes to make them more resilient to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.
Action 2.6.6: Create incentives/rebates package for the retrofitting of households threatened by heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.
Action 2.6.7: Provide financial assistance to local governments to retrofit homes that have been repetitively damaged by floods, severe storms and hail, and bushfires, demolish damaged homes, elevate essential public assets, and move essential public assets.
Action 2.6.8: Establish partnership with insurance companies to map properties at risk of heatwaves and high temperatures, flooding, severe storms and hail, and bushfires and establish thresholds to guide insurance premiums.
Action 2.6.9: Identify barriers and opportunities for retrofitting program based on household tenure (e.g. rental properties, first home, second home).

Program 2.7 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to floodplains are sited landward and/ or relocated.

Action 2.7.1: Assess the vulnerability of existing urban areas to flood events.
Action 2.7.2: Establish a staging process to implement planned retreat of vulnerable areas whilst minimising adverse social impacts.
Action 2.7.3: Investigate the effectiveness of different mechanisms to implement planned retreat, including land acquisition, conservation easements, transfer of development rights, purchase of development rights, tighter rules setbacks and/or tax incentives.
Action 2.7.4: Limit or prohibit rebuilding of damaged structures in defined retreat areas.
Action 2.7.5: Identify suitable areas to accommodate the relocation of flooded communities/population at risk whilst ensuring emergency and health services and facilities continue to be provided to communities/population at risk.
Action 2.7.6: Establish an engagement and communication strategy to consult with communities at risk.
Action 2.7.7: Encourage land owners to relocate structures through tax benefits, voluntary land acquisitions, or conservation easements schemes.
Action 2.7.8: Develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas.
Action 2.7.9: Ensure the restoration and rehabilitation of areas post-retreat.

Program 2.8 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services departments (e.g. disaster management warehouses, disaster coordination centres, evacuation centres, hospitals, aged care facilities) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can continue to operate during emergencies. This should consider threats to communications, transport and water infrastructure.

Action 2.8.1: Assess the vulnerability of essential emergency and health services to flood and bushfires and conduct an inventory to determine which ones require upgrade and/or strategic relocation.
Action 2.8.2: Calculate and allocate funds for construction and implementation of additional essential services and buildings.
Action 2.8.3: Establish a staging process to implement relocation and back-up schemes for essential emergency and health services.
Action 2.8.4: Consult with communities to strategically relocate and/or upgrade essential emergency and health services to ensure communities do not

become disadvantaged in the process.
Action 2.8.5: Investigate feasibility of decentralisation of essential emergency and health services and facilities as a retreat option.
Action 2.8.6: Ensure strategic relocation and upgrade of essential emergency and health services are aligned with strategies forecasted for transportation and communication systems.

Program 2.9 Hazards full disclosure clause: A Hazards Full Disclosure Law is implemented to alert buyers of properties about current and future climate related risks associated with flooding, including riverine and flash floods, and bushfire.

Action 2.9.1: Establish State laws to require sellers of real estate to disclose information to property buyers either before or at the point of contract about risks related to flooding, including riverine and flash floods, bushfire, such as location in a known inundation hazard area and/or setback and building restrictions.
Action 2.9.2: Ensure insurance companies adequately inform their customers about the risks climate change poses to the insurance business and the ability of the industry to pay policyholders' claims.
Action 2.9.3: Develop and update a hazards website to provide information to the public and government, including maps and data related to flooding, including riverine and flash floods, bushfire.
Action 2.9.4: Conduct a review of legislative frameworks to identify and establish necessary amendments to enable enforcement of full hazards disclosure clause.
Action 2.9.5: Consult with community to improve communication about future climate related risks on private properties.

Program 2.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, such as Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water are decentralised and/ or equipped with back-up systems.

Action 2.10.1: Assess the vulnerability of high priority services and buildings to flooding and bushfires and conduct an inventory to determine which ones require decentralisation and back-up.
Action 2.10.2: Calculate and allocate funds for construction and implementation of additional high priority services and buildings in low risk areas.
Action 2.10.3: Encourage the decentralisation of essential services and buildings.
Action 2.10.4: Encourage the establishment of back-up systems to provide spare capacity for essential services and buildings.
Action 2.10.5: Establish a staging process to implement decentralisation and back-up schemes for high priority services and buildings.
Action 2.10.6: Align the staging process for decentralisation and back-up schemes for high priority services and buildings with staging process for strategic relocation and upgrade of essential emergency and health services.
Action 2.10.7: Promote the establishment of decentralised and back-up systems of essential services and buildings in new developments.

Program 2.11 Innovative designs for floods: Innovative engineering and design solutions are employed to minimise vulnerability to flooding in low risk areas.

Action 2.11.1: Encourage residential structures is areas at risk of flooding to have the lowest habitable floor raised or above the highest flood level by 500 mm.
Action 2.11.2: Encourage built areas below the flood level of residential structures subject to flood risk to be designed to allow flood waters to exit (e.g.

walls must be designed to break away in storm events without causing loss of structural integrity).
Action 2.11.3: Encourage buildings to be anchored to the foundation to prevent movement of the structure during flood events.
Action 2.11.4: Encourage residential structures at risk of flooding to have their mechanical, electrical, and plumbing devices elevated above flood level.
Action 2.11.5: Encourage buildings structures subject to flood risk to be designed to be more resilient to flooding by using special coatings and sealings to make the walls impermeable to floodwater.
Action 2.11.6: Encourage essential infrastructure at risk of flooding to be either elevated or built to be more resilient to floods.

Program 2.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.

Action 2.12.1: Investigate the feasibility of raising the height of land and existing development.
Action 2.12.2: Investigate the feasibility of constructing structures that float on the surface of the water, or may be floated occasionally during a flood event, making them largely invulnerable to changing flood levels. (SPUR)
Action 2.12.3: Investigate the feasibility of constructing structures that are designed to withstand flooding or to retain storm water.
Action 2.12.4: Encourage the retention of wetlands to absorb flood, slow erosion and provide habitat.
Action 2.12.5: Ensure emergency and health services and facilities continue to be accessible and operational during and after extreme flood events.

Program 2.13 Mapping of flood vulnerable areas: A program is created to map and catalogue developed building sites that are flooded three or more times over a 10 year-period.

Action 2.13.1: Ensure local authorities keep and maintain a database of currently developed building sites that have been flooded three or more times within the last 10 years.
Action 2.13.2: Ensure information from database is shared and consistent across local authorities, particularly for emergency services.
Action 2.13.3: Target those sites for future land use conversion to reduce the risks to population and to potential property damage.
Action 2.13.4: Investigate funding options for both voluntary and compulsory land acquisition programs of areas identified to be highly vulnerable to floods.

Program 2.14 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.

Action 2.14.1: Reduce pressure on systems or areas at risk of flooding by restricting and discouraging further development.
Action 2.14.2: Introduce multiple land use strategies that account for flood hazards due to climate change impacts. This includes raised buildings with less critical functions (e.g. parking, parkland) at ground level in flood prone areas, natural conservation areas that double as flood management areas,etc.
Action 2.14.3: Implement state legislation to afford protection from legal liability for local councils where they provide advice or make a decision in good faith relating to planning along floodplains and the impact of climate change.

Program 2.15 Flood risk minimisation: A flood preparedness and awareness scheme is initiated to minimise both flash flood and riverine flood risks, including climate change projections, in flood prone areas.

Action 2.15.1: Assess the vulnerability of existing and proposed new urban and peri-urban areas to flooding, including climate change projections that

could exacerbate flood risks.
Action 2.15.2: Identify areas for special protection and priority action (e.g. retrofitting; relocation of structures; land use conversion).
Action 2.15.3: Create an inspection services scheme for homeowners in flood prone areas to help them identify ways in which they could retrofit their homes to make them more resilient to flooding.
Action 2.15.4: Calculate and allocate funds to assist homeowners to retrofit their residences to be more resilient to flooding.
Action 2.15.5: Investigate funding options for voluntary land acquisition programs of areas highly vulnerable to flooding and already identified for land use conversion.
Action 2.15.6: Identify special zoning to trigger more stringent building codes and design standards for new and existing developments in areas highly vulnerable to flooding.
Action 2.15.7: Encourage residents of areas highly vulnerable to flooding to develop and maintain emergency plans, including evacuation procedures.
Action 2.15.8: Ensure emergency and health services and facilities located in areas highly vulnerable to flooding continue to be operational during and after extreme flood events.

Program 2.16 Bushfire risk minimisation: A bushfire preparedness and awareness scheme is initiated to minimise bushfire risks, including climate change projections, in bushfire prone areas.

Action 2.16.1: Assess the vulnerability of existing and proposed new urban and peri-urban areas to bushfire, including climate change projections that could exacerbate bushfire risks.
Action 2.16.2: Identify areas for special protection and priority action (e.g. retrofitting; relocation of structures; land use conversion).
Action 2.16.3: Create an inspection services scheme for homeowners in bushfire prone areas to help them identify ways in which they could retrofit their homes to make them more resilient to bushfire.
Action 2.16.4: Calculate and allocate funds to assist homeowners to retrofit their residences to be more resilient to bushfires.
Action 2.16.5: Investigate funding options for voluntary land acquisition programs of areas highly vulnerable to bushfire and already identified for land use conversion.
Action 2.16.6: Identify special zoning to trigger more stringent building codes and design standards for new and existing developments in areas highly vulnerable to bushfire.
Action 2.16.7: Encourage residents of bushfire prone areas to develop and maintain emergency plans, including evacuation procedures.
Action 2.16.8: Ensure residents of bushfire prone areas continue to have access to emergency and health services and facilities during and after extreme bushfire events.

Program 2.17 Heatwave risk minimisation: A heatwave preparedness and awareness scheme is initiated to minimise heatwave risks, including climate change projections, in heatwave prone areas.

Action 2.17.1: Assess the vulnerability of existing and proposed new urban and peri-urban areas to heatwaves, including climate change projections that could exacerbate heatwave risks.

Action 2.17.2: Identify areas for priority action (e.g. retrofitting; provision of public cool spaces).
Action 2.17.3: Create an inspection services scheme for homeowners to help them identify ways in which they could retrofit their homes to make them more resilient to heatwaves.

Action 2.17.4: Calculate and allocate funds to assist homeowners to retrofit their residences to be more resilient to heatwaves.
Action 2.17.5: Identify special zoning to trigger more stringent building codes and design standards for new and existing developments in areas highly vulnerable to heatwaves.
Action 2.17.6: Encourage residents of areas highly vulnerable to heatwaves to develop and maintain emergency plans, including how to access public cool spaces.
Action 2.17.7: Ensure residents continue to have access to emergency and health services and facilities during heatwave events.

Program 2.18 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.

Action 2.18.1: Enhance existing parklands and acquire new parkland where feasible to improve availability of green spaces and reduce risks from future urban heat island effects (UHIE).

Action 2.18.2: Develop and carry out urban forestry and tree planting programs, and tree protection bylaws to reduce UHIE and sun exposure.

Action 2.18.3: Provide appropriate space and design for recreational needs, including forms of productive recreation such as community gardening, city farms and farmers markets.

Action 2.18.4: Protect, enhance and restore the health and integrity of natural ecosystems such as urban forests and waterways.

Policy 3. SEQ's planning processes must have strong adaptive capacity to improve decision-making to adapt to climate change.

Program 3.1 Leadership development: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Action 3.1.1: Establish a regional consortium for climate change adaptation facilitated through SEQ's Council of Mayors to define priorities for research, priority state climate adaptation research and monitoring needs, proposed resources and timeframes to implement actions and programs, and strategic planning, including regional policy statements to promote and/or improve adaptation to climate change impacts.
Action 3.1.2: Establish a working group within SEQ's Council of Mayors to improve collaboration across agencies and governments, including local government, state and federal agencies, for the implementation of climate change adaptation strategies.
Action 3.1.3: Ensure partnering agencies adopt a policy collaboration scheme to optimise the implementation of cross-border and cross-agency climate change adaptation strategies.
Action 3.1.4: Initiate a public education campaign to raise awareness and inform business and the community about climate change risks.
Action 3.1.5: Identify and support climate change champions.

Program 3.2 Capacity building: Local governments' capacity must continue to be built through improved knowledge and skills about climate change.

Action 3.2.1: Establish partnerships with research agencies to ensure the best available science informs climate adaptation decision-making.
Action 3.2.2: Compile and disseminate strategies, tools and information generated through partnerships for use by local governments when updating their local and general plans and to inform public discussion on climate change risks.
Action 3.2.3: Establish institutional collaboration between larger and smaller local authorities within the region to provide mentoring programs for staff focused on climate change adaptation.
Action 3.2.4: Implement training and individual development programs for staff focused on identifying and evaluating climate risks.
Action 3.2.5: Implement an adaptive management cycle focused on a monitoring, evaluation and report (MER) approach to enable decision-makers to learn from successes and failures when developing and implementing climate change adaptation initiatives/strategies.

Program 3.3 Risk communication on climate change: Communication of climate change risks to decision-makers and wider community (flooding, storm surge, heatwave and sea level rise) must be improved.

Action 3.3.1: Establish a partnership between pertinent federal and state agencies and the research community to develop a database of information related to climate change risks to be used by decision-makers to reduce climate change impacts.
Action 3.3.2: Develop and implement a communication and engagement strategy with vulnerable communities to examine adaptive strategies available to state and local agencies to prepare for potential climate change impacts.

Program 3.4 Risk allocation mechanisms: Climate change risks must be incorporated into decision-making processes.

Action 3.4.1: Implement a hazard avoidance policy adopting the most risk-averse approach for minimizing the adverse effects of climate change to carefully consider new development within areas vulnerable to climate change impacts, and to consider prohibiting development of undeveloped, vulnerable areas containing critical habitat or opportunities for habitat creation.
Action 3.4.2: Integrate climate risk and adaptation assessments into business and community planning.
Action 3.4.3: Integrate climate risks and adaptation into existing and emerging policy and planning frameworks and strategies in key socio-economical and environmental areas.
Action 3.4.4: Accept losses where there are no other acceptable or feasible options. Losses could be related to habitats and/or ecosystems; individuals' property and financial losses following extreme weather events; public assets; insurance companies' losses as part of their business.
Action 3.4.5: Define responsibilities for losses or risks across governments, private sector and insurance companies.
Action 3.4.6: Provide incentives that promote risk adverse behaviour when purchasing and developing properties. This would include linking financial terms and conditions to climate risk and subsidising technologies that are consistent with contributing to avoiding or reducing climate risks.
Action 3.4.7: Define developers' responsibilities in development located in vulnerable areas in the next 50 years (e.g. fee to cover the costs of potential emergency response, or to improve resilience of infrastructure that services the new development to natural hazards; developer must design the new development and its supporting infrastructure to be more resilient to natural hazards).
Action 3.4.8: Define landowners' responsibilities in locations subject to natural hazards in the next 50 (e.g. landowner agrees to retrofit properties, undertake measures to reduce impacts from natural hazards).
Action 3.4.9: Develop regulatory policies for insurance companies to guide private insurers in dealing with properties located in areas vulnerable to climate change impacts, including natural hazards.
Action 3.4.10: Investigate the feasibility of establishing partnerships between government and insurance companies to determine conditions to guide

insurance of private and public assets based on improved risk mitigation mechanisms (e.g. flood mitigation plans are developed and implemented to reduce the risk of recurrent floods in low-lying areas).

Program 3.5 Professional and sub-professional education and training: A mandatory training program is created to educate professionals and sub-professionals in relevant fields (e.g. planning, architecture, surveying, building certification, real estate agents, engineering, and construction management) on the need to incorporate adaptation to climate change and natural hazards as a basis for establishing design criteria for new infrastructure and housing estates.

Action 3.5.1: Encourage universities, vocational training and TAFE colleges in SEQ to develop educational programs for building design and construction professionals, planners, and those in other pertinent fields such as real estate agents, focusing on vulnerability to climate change and adaptation methodologies.
Action 3.5.2: Include compulsory training on climate change as part of professional and sub-professional membership accreditation and certification (e.g. PIA, EIANZ, AILA).
Action 3.5.3: Implement continued professional development programs for professionals and sub-professional focused on identifying and evaluating climate risks.
Action 3.5.4: Promote climate change awareness through education and training (formal and informal), including integration into curriculum and targeted programs or activities.

Program 3.6 Anticipatory planning response: The vulnerability of existing settlements in SEQ to climate change-exacerbated hazards, including natural hazards must be reduced through pro-active action.

Action 3.6.1: Assess the vulnerability, socially and physically, of existing settlements in SEQ to climate change impacts, including natural hazards.
Action 3.6.2: Reduce vulnerability of identified areas by encouraging the retrofitting of private properties at low and medium risk from climate change impacts, including natural hazards.
Action 3.6.3: Reduce vulnerability of identified areas by encouraging the relocation of building structures and infrastructure at high risk from climate change impacts, including natural hazards, whilst ensuring communities continue to have access to emergency and health services and facilities.
Action 3.6.4: Reduce vulnerability of identified areas by acquiring high risk properties through voluntary land acquisition, rolling easements, transfer of development rights, and/or purchase of development rights.
Action 3.6.5: Establish partnerships with the private sector (development industry, insurance companies, real estate agencies) to increase leadership capacity of local governments to undertake anticipatory planning responses to address climate change impacts, including natural hazards.
Action 3.6.6: Establish an engagement and communication strategy to consult with communities at risk.
Action 3.6.7: Implement state legislation to afford protection from legal liability to local councils where they provide advice or make a decision in good faith relating to anticipatory planning response to address climate change impacts, including natural hazards.
Action 3.6.8: Ensure state and local governments develop a long term post-disaster recovery plan. This plan should identify policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of a community after a disaster.
Action 3.6.9: Integrate long term post-disaster recovery considerations into pre-disaster plans of government agencies leading recovery processes.

D2: Coastal Management Adaptation Options

(refer to Section 2 of the Supplementary Report for a full description of Policies, Program, Action and Implementation recommendations)

Overarching Goal: Adapt coastal settlements to the risk of current and future coastal hazards using a combination of programs involving defence, retreat and accommodation approaches while improving the capacity of coastal communities to adapt.

Key words: coastal management, defend, retreat, accommodate, capacity building

Defend

Policy 1. Sandy shorelines must be prepared for future coastal erosion events associated with climate variability and change.

Program 1.1 Beach nourishment in a changing climate: Instigate a program to defend the current position of the shoreline through erosion control involving a combination of beach nourishment, dune restoration and (re)construction, and hard coastal defences.

Program 1.2 Innovative erosion control approaches: Identify and assess innovative approaches to address coastal erosion, including hard structures, beach drainage and emerging technologies.

Program 1.3 Dunes restoration in a changing climate: Identify, restore and maintain coastal dune systems threatened by the impact of sea level rise and extreme erosion.

Policy 2. Coastal settlements must be defended from the risks of current and future storm tides which may be affected by climate variability and change.

Program 2.1 Storm tides defence system: Avoid inundation of vulnerable coastal communities under current and future storm tide events by combining hard and soft defence options to minimize the risk of storm tide inundation.

Retreat

Policy 3. Coastal settlements should retreat from vulnerable shores when defence is not feasible in the future and the natural functions of shores must be restored.

Program 3.1 Retreat from high coastal hazard areas: Develop innovative methods to retreat from areas at risk, including voluntary and compulsory mechanisms such as land swap, land purchase and resUPMtion, land surrender, rolling easements and coastal setbacks to retreat from areas at risk from erosion and storm tides.

Program 3.2 Restoration of coastal environments: Remove buildings and infrastructure affected by erosion and inundation and those within retreat areas and restore ecosystem functions of beaches, dunes, wetlands and riparian environments

Accommodate

Policy 4. Coastal settlement in flood prone areas must be designed to accommodate current and future storm tides.

Program 4.1 Space for water: New space should be identified to allow extreme water levels to be accommodated during storm tides.

Program 4.2 Design standards for buildings and infrastructure: Buildings and infrastructure designs can be improved to accommodate extreme water levels during storm tides. These changes should apply to new and existing buildings and infrastructure.

Capacity Building

Policy 5. The capacity of the community and institutions to face current and future coastal hazards must be improved.

Program 5.1 Community capacity and engagement programs: Create capacity and engagement programs for coastal rehabilitation and restoration including programs for dunes and wetlands restoration.

Program 5.2 Enhanced coastal education Programs: Integrate climate adaptation into existing school education programs (primary and secondary levels).

Program 5.3 Enhanced institutional capacities to manage coastal hazards: Build capacity of council officers and other relevant organization to manage coastal hazard areas in a changing climate.

Statutory planning | Non-statutory planning | Non-statutory and/or statutory planning

Figure D2.1: **Coastal Management Adaptation Options Framework**

Legend: Statutory planning | Non-statutory planning | Non-statutory and/or statutory planning

Policy 1. Sandy shorelines must be prepared for future coastal erosion events associated with climate variability and change.
Program 1.1 Beach nourishment in a changing climate: Instigate a program to defend the current position of the shoreline through erosion control involving a combination of beach nourishment, dune restoration and (re)construction, and hard coastal defences. **Action 1.1.1:** Set-up a monitoring system for shoreline position and sand volumes. **Action 1.1.2:** Identify strategic sand deposits including rivers, offshore and quarries **Action 1.1.3:** Identify current and future volumes needed for sand replenishment. **Action 1.1.4:** Assess the best available option or combination of options for beach nourishment in the future. **Action 1.1.5:** Couple dune restoration and beach nourishment programs.
Program 1.2 Innovative erosion control approaches: Identify and assess innovative approaches to address coastal erosion, including hard structures, beach drainage and emerging technologies. **Action 1.2.1:** Assess the status and efficiency of current coastal erosion control approaches. **Action 1.2.2: I**nvestigate innovative solutions for coastal erosion control, considering the impact of sea level rise and changing wave climate.
Program 1.3 Dunes restoration in a changing climate: Identify, restore and maintain coastal dune systems threatened by the impact of sea level rise and extreme erosion. **Action 1.3.1:** Set-up a monitoring system for dune volumes and ecosystem health. **Action 1.3.2:** Identify vulnerable dune systems. **Action 1.3.3:** Promote programs for community dunes restoration. **Action 1.3.4:** Assess the impact of sea level rise on dune functions, including sediments needs to cope with extreme storms. **Action 1.3.5:** Couple dune restoration and beach nourishment programs.

Policy 2. Coastal settlements must be defended from the risks of current and future storm tides which may be affected by climate variability and change.
Program 2.1 Storm tides defence system: Protect vulnerable coastal communities threatened by current and future storm tide events by combining hard and soft defence options to minimize the risk of inundation.

Action 2.1.1: Asses the vulnerability of existing urban areas to rising sea levels and storm surges.
Action 2.1.2: Research and analysis to determine alternative solutions to defence mechanisms by assessing the engineering, economic, social and environmental aspects of whether or not selected sections of the coasts can or should be protected.
Action 2.1.3: Identify and define protection zones, i.e. areas with dense urban development that permit coastal armoring.
Action 2.1.4: Investigate the feasibility of different mechanisms used to implement coastal defence, including soft and/or hard armoring techniques.
Action 2.1.5: Allocate funding to enable the construction and management of coastal defence structures.
Action 2.1.6: Establish a staging process for the implementation of coastal defence structures to protect identified areas at risk (UPM 1.8)
Action 2.1.7 Conduct a review of legislative frameworks to identify and conduct necessary amendments to enable implementation of coastal defence program.
Action 2.1.8: Improve understanding of future storm tides through funding of research Programs into future cyclone patterns and the impact on storm tide generation and propagation.

Policy 3. Coastal settlements should retreat from vulnerable shores when defence is not feasible in the future and the natural function of shores must be restored.

Program 3.1 Retreat from high coastal hazard areas: Develop innovative methods to retreat from areas at risk, including voluntary and compulsory mechanisms such as land swap, land purchase and resumption, land surrender, rolling easements and coastal setbacks to retreat from areas at risk from erosion and storm tides.

Action 3.1.1: Assess the vulnerability of existing urban areas to rising sea levels, erosion and storm surges.
Action 3.1.2: Establish a staging process to implement planned retreat from vulnerable areas.
Action 3.1.3: Investigate the effectiveness of different mechanisms to implement planned retreat, including land acquisition, rolling easements, transfer of development rights, stronger setbacks and/or tax incentives.
Action 3.1.4: Limit or prohibit rebuilding of damaged structures in defined retreat areas.
Action 3.1.5: Limit or prohibit rebuilding of damaged structures in defined retreat areas.
Action 3.1.6: Identify suitable areas to accommodate the relocation of coastal communities/population at risk.
Action 3.1.7: Establish a communication strategy to consult with coastal communities at risk.
Action 3.1.8: Encourage land owners to relocate structures through tax benefits, voluntary acquisitions, or conservation easements schemes.
Action 3.1.9: Liaise with insurance companies to develop regulatory policies to guide private insurers in dealing with properties in vulnerable areas.

Program 3.2 Restoration of coastal environments: Remove buildings and infrastructure affected by erosion and inundation and those within retreat areas and restore ecosystem functions of beaches, dunes, wetlands and riparian environments.

Action 3.2.1: Assess the potential reuse of settlements and infrastructure for compatible uses.

Action 3.2.2: Assess the costs of removal of settlements and infrastructure.
Action 3.2.3: Prioritize the removal of settlements and infrastructure.
Action 3.2.4: Restore beaches and dunes.
Action 3.2.5: Restore wetlands and riparian vegetation.
Action 3.2.6: Create recreational areas.

Policy 4. Coastal settlement in flood prone areas must be designed to accommodate current and future storm tides.
Program 4.1 Space for water: New space should be identified to allow extreme water levels to be accommodated during storm tides **Action 4.1.1** Identify areas at risk from coastal inundation currently and in the future. **Action 4.1.2:** Assess costs and benefits of reserving land for inundation under extreme storms. **Action 4.1.3:** Apply land management techniques (e.g. land purchase) to allow space for water. **Action 4.1.4:** Restore acquired land for low impact uses (e.g. parklands).
Program 4.2 Design standards for buildings and infrastructure: Buildings and infrastructure designs can be improved to accommodate extreme water levels during storm tides. These changes should apply to new and existing buildings and infrastructure. **Action 4.2.1:** Incorporate sea level rise and storm tide criteria in the design standards to retrofit existing buildings and for new developments. **Action 4.2.2:** Incorporate sea level rise and storm tide criteria in the design standards for new and upgraded stormwater systems and roads.

Policy 5. The Capacity of the community and institutions to face current and future coastal hazards must be improved.
Program 5.1 Community capacity and engagement programs: Create capacity and engagement programs for coastal rehabilitation and restoration including programs for dunes and wetlands restoration. **Action 5.1.1:** Enhance community engagement programs for dune restoration (e.g. DuneCare). **Action 5.2.2:** Enhance community engagement programs for wetland and riparian vegetation restoration (e.g. WetlandCare).

Action 5.1.3: Promote training programs for coastal communities in dunes, wetlands and riparian restoration.
Program 5.2 Enhanced coastal education Programs: Integrate climate adaptation into existing school education programs (primary and secondary levels) **Action 5.2.1:** Educational programs – Integrate climate adaptation in primary and secondary schools curricula.
Program 5.3 Enhanced institutional capacities to manage coastal hazards: Build capacity of council officers and other relevant organization to manage coastal hazard areas in a changing climate. **Action 5.3.1:** Create training packages for coastal managers and planners within councils.

D3: Physical Infrastructure Adaptation Options

(refer to Section 3 of the Supplementary Report for a full description of Policies, Program, Action and Implementation recommendations)

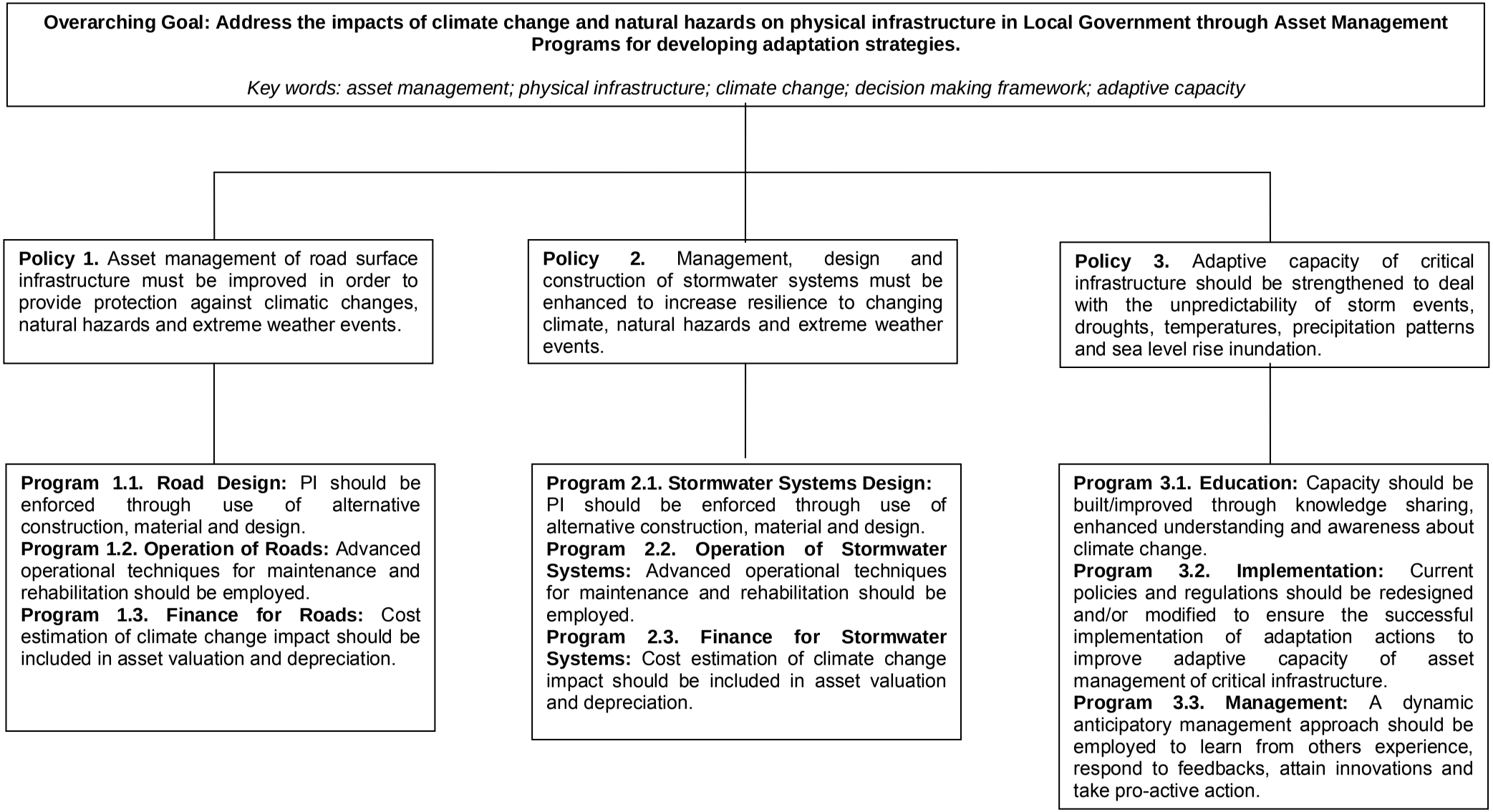


Figure D3.1: **Physical Infrastructure Adaptation Options Framework**

Policy 1. Asset management of road surface infrastructure must be improved in order to provide protection against climatic changes, natural hazards and extreme weather events.
Program 1.1 Road Design: PI should be enforced through use of alternative construction, material and design. **Action 1.1.1:** Further research into impacts of climate change and extreme events on: - limitations of current practices; - increased heavy vehicular loading; - current asset conditions and deterioration hot spots; - building and development controls; - existing/alternative material properties; - maintenance operation; and, - alternative tools (e.g. Facebook, twitter) to improve risk communication to/with broader communities. **Action 1.1.2:** Change design standards and material properties for new constructions, maintenance and rehabilitations works. **Action 1.1.3:** Retrofitting of existing road infrastructure (e.g. additional water proof surface, improved concrete slab joint filler). **Action 1.1.4:** Utilise alternative design of road sign and signal to cope with natural hazards (e.g. solar powered signage). **Action 1.1.5:** Enhance road design standards to cope with uncertainties in rainfall intensity. **Action 1.1.6:** Integrated infrastructure design approach: - stormwater linked to roads; - in order to increase infrastructures resilience to climate change and natural hazards at the planning and design stage their interdependencies should be considered (e.g. construction of roads away from vulnerable stormwater networks).
Program 1.2 Operation of Roads: Advanced operational techniques for maintenance and rehabilitation should be employed. **Action 1.2.1:** Apply research findings of program 1.1 on construction, maintenance and operational techniques. **Action 1.2.2:** Investment: - expected increased maintenance durations/frequencies; and, - impact of alternative techniques as recommended from research. **Action 1.2.3:** Increase monitoring of infrastructure condition and deterioration rates. **Action 1.2.4:** Use technology for improved information management for impact assessment, aggressive maintenance, making real-time information available to stakeholders. **Action 1.2.5:** Knowledge sharing and risk communication: - establish partnerships with research agencies (e.g. ARRB and Austroads) to ensure the best available science informs climate adaptation decision-making; and, - compile and disseminate strategies, tools and information generated through partnerships for use by local governments when updating their local and general plans and to inform public discussion on climate change risks. **Action 1.2.6:** Improve resilience to flood or re-site infrastructure and plan transport routes and roads to avoid disruption by flooding activities.

Action 1.2.7: Develop plans for alternative routes to be used in the event of road failure or inundation for emergency services. Prioritise keeping these roads operational during natural hazards.
Action 1.2.8: Minimise sediment from industrial sites to reduce blockage.

Program 1.3 Finance for Roads: Cost estimation of climate change impact should be included in asset valuation and depreciation.

Action 1.3.1: Asset valuation by evaluating current physical condition of road network to enable identification of required funds.
Action 1.3.2: Investigate and establish funding opportunities for increasing investment to support further research and operation activities.
Action 1.3.3: Establish redundancy fund for rapid action to re-operationalise damaged or closed roads due to extreme events.
Action 1.3.4: Identify funding options to cover cost of deterioration and linked with climate change and prepare for increased required investment.
Action 1.3.5: Calculate and allocate funds for roads identified as critical to emergency operations.

Policy 2. Management, design and construction of stormwater systems must be enhanced to increase resilience to changing climate, natural hazards and extreme weather events.

Program 2.1 Stormwater Systems Design: PI should be enforced through use of alternative construction, material and design.

Action 2.1.1: Further research into impacts of climate change and extreme events on:
- limitations of current practices;
- current asset conditions and capacity hot spots (drainage/storage etc).
    - building and development controls;
    - Improving water harvesting and quality strategies;
    - existing/alternative material properties;
    - maintenance operation; and,
    - alternative tools (e.g. facebook, twitter) to improve risk communication to/with broader communities.

Action 2.1.2: Change design standards and material properties for new constructions, maintenance and rehabilitations works.
Action 1.1.3: Redesign/modify stormwater networks that will protect the community and other infrastructures from increased rainfall and runoff.
Action 2.1.4: Design/modify existing regulations to increase adaptive capacity.
Action 2.1.5: Incorporate the design of localised water storage, treatment and reuse technologies by utilising the application of alternative technologies at lot, neighbourhood or district residential or commercial/industrial scales as part of WSUD approach.
Action 2.1.6: Integrated infrastructure design approach:
- stormwater linked to roads;
- in order to increase infrastructures resilience to climate change and natural hazards at the planning and design stage their interdependencies should be considered (e.g. improvement of stormwater systems to reduce inundation of roads).

Program 2.2 Operation of Stormwater Systems: Advanced operational techniques for maintenance and rehabilitation should be employed.

Action 2.2.1: Promote use of Water Sensitive Urban Design (WSUD) approaches to integrate the following potential planning and design opportunities into the built environment of cities and towns:

- reuse of stormwater as alternative source of water to conserve potable supplies;
- detention, rather than rapid conveyance, of stormwater;
- reuse, storage and infiltration of stormwater, instead of drainage system augmentation;
- use of vegetation for stormwater filtering purposes;
- treating stormwater to increase water quality for reuse and/or discharge(e.g. swales, wetlands, bioretention, rainwater tanks); and,
- capture or harvest urban stormwater for reuse in order to contribute to water conservation and water quality.

Action 2.2.2: Through education and training increase public awareness and knowledge of stakeholders involved in water issues.
Action 2.2.3: Set maintenance plans for procedures and schedules of water infrastructure.
Action 2.2.4: Use technology for improved information management for: impact assessment, aggressive maintenance; making real-time information available to stakeholders.
Action 2.1.5: Consult end users/stakeholders during formulation and implementation.
Action 2.1.6: Retrofitting of existing stormwater networks (e.g. corrosion protection, drainage covers).
Action 2.1.7: Improve design and construction of water systems to increase monitoring of water infrastructure (e.g. use of remote monitoring and sensing devises).

Program 2.3 Finance for Stormwater Systems: Cost estimation of climate change impact should be included in asset valuation and depreciation.

Action 2.3.1: Asset valuation, evaluate current physical condition of stormwater network to enable identification of required funds.
Action 2.3.2: Investigate and establish funding opportunities for increasing investment to support further research and operation activities.
Action 2.3.3: Establish redundancy fund for rapid action to re-operationalise damaged stormwater network due to extreme events.
Action 2.3.4: Identify funding options to cover cost of deterioration and linked with climate change and prepare for increased required investment.

Policy 3. Adaptive capacity of critical infrastructure should be strengthened to deal with the unpredictability of storm events, droughts, temperatures, precipitation patterns and sea level rise inundation.

Program 3.1 Education: Capacity should be built/improved through knowledge sharing, enhanced understanding and awareness about climate change.

Action 3.1.1: Research to recognise the extent to which adaptive capacity is already being considered in decision-making frameworks and policies.
Action 3.1.2: Provide training and educational opportunities to stakeholders to involve in scenario planning processes which stimulate thinking about the future, how different institutions shape it, and how surprises, unexpected consequences and possible responses may unfold.

Action 3.1.3: Improve communication of climate change risks and infrastructure vulnerability to decision-makers and wider community thereby changing management from reactive to proactive. **Action 3.1.4:** Encourage public and private educational institutions to develop programs for professionals with a specific focus on adaptive capacity and vulnerability to climate change and adaptation methodologies. **Action 3.1.5:** Include training programs about climate change as part of professional membership accreditation/certification. **Action 3.1.6:** Implement continued professional development programs focused on identifying and evaluating climate risks. **Action 3.1.7:** Promote climate change awareness through education and training (formal and informal), including integration into curriculum and targeted programs or activities. **Action 3.1.8:** Establish partnerships with research agencies to ensure the best available science informs climate adaptation decision-making.
Program 3.2 Implementation: Current policies and regulations should be redesigned and/or modified to ensure the successful implementation of adaptation actions to improve adaptive capacity of asset management of critical infrastructure. **Action 3.2.1:** Identify environmental factors threatening infrastructure performance. **Action 3.2.2:** Identify determinants of and constraints on adaptive capacity. **Action 3.2.3:** Enhance future adaptive capacity by evaluating interdependencies of and the relationships between current adaptive capacity of design, operations and finance. **Action 3.2.4:** Consider economic costs associated with compliance and/or enforcement of regulations. **Action 3.2.5:** Advance and retain state of the art or novel governance by transferring to address complex challenges of resource sharing and availability. **Action 3.2.6:** Change standards or methods for design, operation and finance to further adaptive capacity. **Action 3.2.7:** Identify, design and implement monitoring and enhancing techniques of adaptive capacity. **Action 3.2.8:** Improve knowledge sharing and collaboration across agencies and all levels of governments for effective implementation of adaptation strategies. **Action 3.2.9:** Develop or advance communication and engagement strategies with vulnerable communities. **Action 3.2.10:** Implement a hazard avoidance procedure for minimising the adverse effects of climate change when planning and constructing new infrastructure within areas vulnerable to climate change impacts. **Action 3.2.11:** Define responsibilities for losses or risks across governments, private sector and insurance companies (e.g. fee to cover the costs of potential emergency response, or to improve resilience of infrastructure that services the new development to natural hazards; developer must design the new development and its supporting infrastructure to be more resilient to natural hazards).
Program 3.3 Management: A dynamic anticipatory management approach should be employed to learn from others experience, respond to feedbacks, attain innovations and take pro-active action. **Action 3.3.1:** Embrace national and/or international adaptation practices or cases (i.e. integrating stormwater and road infrastructures). **Action 3.3.2:** Determine and adopt techniques for transition towards adaptive management methods. **Action 3.3.3:** Indentify and/or develop indicators for infrastructure coping capacity.

D4: Emergency Management Adaptation Options

(refer to Section 4 of the Supplementary Report for a full description of Policies, Program, Action and Implementation recommendations)

Overarching Goal: To increase the resilience of SEQ's emergency management sector in a changing climate.

Key words: emergency management, climate change, community preparedness, long term disaster recovery, capacity building, community leadership

Prevention

Policy 1. State and local governments integrate long term post-disaster recovery considerations into pre-disaster planning processes.

Program 1.1: Long term post-disaster recovery plan: State and Local governments develop a long term post-disaster recovery plan. This plan should identify policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of a community after a disaster.
Program 1.2: Post-disaster recovery in pre-disaster plans: Long term post-disaster recovery considerations are integrated into pre-disaster plans of government agencies leading recovery processes.
Program 1.3: Community engagement: Communities are engaged in the development of the long-term post-disaster recovery plans.

Policy 2. A series of programs to integrate emergency management and urban planning and management processes to more effectively reduce vulnerability of communities to climate change.

Program 2.1: Emergency management integrated into land use planning and development: Emergency management considerations are integrated into urban planning decisions related to land use planning and development.
Program 2.2: Emergency management integrated into state planning policies: The integration of emergency management into state planning policies is improved.
Program 2.3: Strategic relocation and upgrade of essential emergency services: Emergency services and facilities (e.g. disaster management warehouses, disaster coordination centres, evacuation centres) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks to ensure these services and facilities can continue to operate during emergencies. This should include considering threats to infrastructure, such as communications and roads.
Program 2.4: Capacity building and training program: A capacity building and training program on emergency management, climate change and urban and regional planning is developed and implemented.

Preparedness

Policy 3. A series of programs will be introduced to improve the levels preparedness of communities to climate change and new climatic risks.

Program 3.1: Preparedness of vulnerable communities: The preparedness of vulnerable communities to current and future climatic risks is improved.
Program 3.2: Preparedness of private and community sectors: The preparedness of private and community sectors to climate change and new climatic risks is improved.
Program 3.3: Real estate sector and hazard awareness: The real estate sector is engaged to improve hazard awareness amongst property owners.
Program 3.4: Community education and awareness raising campaigns for vulnerable groups: Community education and awareness raising campaigns/initiatives targeted at vulnerable groups, including new residents and seasonal visitors, are developed and implemented. These campaigns will focus on natural hazard preparedness, response (including evacuation) and recovery, and potential climate change implications for the area and communities targeted to promote greater ownership of hazard risks and more self-reliant and empowered individuals and communities.
Program 3.5: Bushfire Community Training Package: Continue to implement Queensland's Bushfire Community Training Package.

Response

Policy 4. An integrated group of programs to support and enhance the emergency management capacity and capability of local governments in light of the changing risk profile due to climate change.

Program 4.1: Redundancy and back up for essential emergency management services and facilities: High priority emergency management services and facilities, such as Local Disaster Coordination Centres, evacuation centres, hospitals and alternative access routes are decentralised and/or equipped with back-up systems.
Program 4.2: Local government emergency management capacity: The emergency management capacity of local governments is improved.
Program 4.3: Communication between local councils: Improved and increased communication between emergency management personnel across local councils is facilitated.
Program 4.4: 'Support our Heroes': Continue to implement Queensland's Support our Heroes Program to strengthen the response capacity of SES and Rural Fire Service.

Policy 5. Stronger regional collaboration between local governments for emergency events is facilitated through a buddy system sponsored by the Council of Mayors (SEQ).

Program 5.1: Mutually supportive councils: Councils establish and maintain agreements with each other to provide assistance if required during an emergency event.

Recovery

Policy 6. A series of programs facilitated by emergency management agencies to more effectively support the role of communities in disaster response and recovery to promote greater community resilience to extreme weather events and climate change.

Program 6.1: Community training programs: Community training programs in response and recovery are developed for community groups.
Program 6.2: Community Leadership: Community leadership during and after disasters is supported to promote improved disaster response and recovery.

Figure D4.1: **Emergency Management Adaptation Options Framework**

Policy 1. State and local governments integrate long term post-disaster recovery considerations into pre-disaster planning processes.
Program 1.1 Long term post-disaster recovery plan: State and Local governments develop a long term post-disaster recovery plan. This plan should identify policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of a community after a disaster. **Action 1.1.1:** Identify appropriate structure, process and stakeholders for development of this plan. **Action 1.1.2:** Organise a multi-stakeholder sub-group to be responsible for the development of this plan. **Action 1.1.3**: Use scenario planning as one of the tools to determine long-term post-disaster recovery and redevelopment needs. **Action 1.1.4:** Conduct annual testing exercises to rehearse pre and post disaster decision making and update plan when necessary. **Action 1.1.5:** Ensure the plan emphasises seizing opportunities in post-disaster phase for hazard mitigation and community improvement. **Action 1.1.6:** Local governments to investigate in pre-disaster phase different funding options, in addition to NDRRA and SDRA, for redevelopment and recovery activities.
Program 1.2 Post-disaster recovery in pre-disaster plans: Long term post-disaster recovery considerations are integrated into pre-disaster plans of government agencies leading recovery processes. **Action 1.2.1:** Integrate long term post-disaster recovery considerations in State, regional and local statutory plans and policies (e.g. SPPs, SEQ Regional Plan, planning schemes, corporate plans, community plans). **Action 1.2.2:** Integrate long term post-disaster recovery considerations into non-statutory plans (e.g. Local Disaster Management Plan, Qld Health strategic plan).
Program 1.3 Community engagement: Communities are engaged in the development of the long-term post-disaster recovery plans. **Action 1.3.1:** Pilot test the development of a long term post-disaster recovery plan with a few communities to inform the process of developing the long term recovery plan before expanding the process to a wider number of communities. **Action 1.3.2:** Engage communities by holding community forums and workshops at the start and throughout the process of plan development.

Policy 2. A series of programs to integrate emergency management and urban planning and management processes to more effectively reduce vulnerability of communities to climate change.
Program 2.1 Emergency management integrated into land use planning and development: Emergency management considerations are integrated into urban planning decisions related to land use planning and development. **Action 2.1.1:** Ensure EMQ has a concurrence agency role in development applications (DAs) within the Integrated Development Assessment System (IDAS). **Action 2.1.2:** Integrate emergency management considerations in Structure Plans when implementing urban consolidation and urban renewal programs, and master planned communities. **Action 2.1.3:** Integrate emergency management considerations into local Statutory Plans (e.g. Planning schemes, corporate plans). **Action 2.1.4:** Integrate emergency management considerations into local non-Statutory Plans (e.g. Transport Plans). **Action 2.1.5:** EMQ and SDI&P to develop an internal education program for state and local government planners on emergency management issues and requirements with regard to climate change adaptation (e.g. workshops). **Action 2.1.6:** Review and modify the National planning systems principles to consider emergency management.
Program 2.2 Emergency management integrated into state planning policies: The integration of emergency management into state planning policies is improved. **Action 2.2.1:** Review and revise the SPP 1.03 to incorporate emergency management and climate change adaptation considerations. **Action 2.2.2:** Review the SPP 3/11 to incorporate emergency management considerations for developments in the coastal zone.
Program 2.3 Strategic relocation and upgrade of essential emergency services: Emergency services and facilities (e.g. disaster management warehouses, disaster coordination centres, evacuation centres) are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks to ensure these services and facilities can continue to operate during emergencies. This should include considering threats to infrastructure, such as communications and roads. **Action 2.3.1:** Assess the vulnerability of essential emergency management services to natural hazards and conduct an inventory to determine which ones require upgrade and/or strategic relocation. **Action 2.3.2:** Calculate and allocate funds for relocation and upgrading of essential emergency management services. **Action 2.3.3:** Establish staging process to implement relocation and upgrade of essential emergency management services. **Action 2.3.4:** Engage community on decentralisation of essential emergency management services to ensure communities do not get disadvantaged. **Action 2.3.5:** Investigate feasibility of decentralisation of essential emergency management services and facilities as a retreat option.
Program 2.4 Capacity building and training program: A capacity building and training program on emergency management, climate

change and urban and regional planning is developed and implemented.

Action 2.4.1: Work with tertiary institutions, PIA, EIANZ and TAFE to incorporate consideration of climate change adaptation and emergency management as a consistent theme in professional development training modules for land use planners, both at Certified Practicing Planner level and for other planning professionals.
Action 2.4.2: Develop National Guide to climate change and emergency management in land use planning to ensure consideration of disaster risk implications of CC in development of future policies, codes and standards to do with the built environment and land use planning.
Action 2.4.3: Implement training and continuing professional development (CPD) programs on emergency management for sectors involved in land use planning and development decisions.
Action 2.4.4: Implement training and capacity building programs on urban and regional planning for emergency management staff in local and state governments.

Policy 3. A series of programs will be introduced to improve the levels preparedness of communities to climate change and new climatic risks.
Program 3.1 Preparedness of vulnerable communities: The preparedness of vulnerable communities to current and future climatic risks is improved. **Action 3.1.1:** Continue to implement Qld's Disaster Preparedness in vulnerable communities programme to develop community awareness and improve individual, household and business capacity. **Action 3.1.2:** Build capacity of disadvantaged communities to effectively respond to the potential social and economic impacts of climate change. **Action 3.1.3**: Extend 'preparedness and awareness' programs to communities where risk of extreme climatic events has increased. **Action 3.1.4:** Provide community safety programmes that factor in climate change. **Action 3.1.5:** Establish information sharing and collaborative partnerships with community service providers to manage risks of climate change.
Program 3.2 Preparedness of private and community sectors: The preparedness of private and community sectors to climate change and new climatic risks is improved. **Action 3.2.1:** Provide emergency management and climate change adaptation training programmes for private and community sector. **Action 3.2.2:** Private and community sector organisations to develop and frequently revise their disaster management plan. **Action 3.2.3:** Private and community sector to assess climate change implications on their operations.
Program 3.3 Real estate sector and hazard awareness: The real estate sector is engaged to improve hazard awareness amongst property owners.

Action 3.3.1: Establish State and Federal full disclosure laws to require sellers of real estate to disclose information on natural hazards that can put property at risk. **Action 3.3.2:** Establish stronger requirements/ regulations for real estate disclosure to provide coastal property buyers information of the potential perils associated with developing or purchasing property seaward of the [state's] oceanfront setback line.
Program 3.4 Community education and awareness raising campaigns for vulnerable groups: Community education and awareness raising campaigns/initiatives targeted at vulnerable groups, including new residents and seasonal visitors, are developed and implemented. These campaigns will focus on natural hazard preparedness, response (including evacuation) and recovery, and potential climate change implications for the area and communities targeted to promote greater ownership of hazard risks and more self-reliant and empowered individuals and communities. **Action 3.4.1:** Identify the different socio-economic profiles and possible vulnerable groups in communities. **Action 3.4.2:** Organise forums and develop information specifically targeted at the different vulnerable groups identified. **Action 3.4.3:** Develop community education and awareness raising programmes targeted at new migrant communities.
Program 3.5 Bushfire Community Training Package: Continue to implement Queensland's Bushfire Community Training Package. **Action 3.5.1:** Use best available science to determine changing profile of bushfire risks to communities due to climate change. **Action 3.5.2:** Support and develop a network of Volunteer Community Education Officers to deliver bushfire education to their local communities. **Action 3.5.3:** Build community awareness of nature and risk of bushfires, including the changing risks due to climate change, and measures to prepare and protect lives, property and the environment.

Policy 4. An integrated group of programs to support and enhance the emergency management capacity and capability of local governments in light of the changing risk profile due to climate change.
Program 4.1 Redundancy and back up for essential emergency management services and facilities: High priority emergency management services and facilities, such as Local Disaster Coordination Centres, evacuation centres, hospitals and alternative access routes are decentralised and/or equipped with back-up systems. **Action 4.1.1:** Assess vulnerability of essential emergency management services and facilities to extreme weather events and conduct an inventory to determine which ones require redundancy and back-up. **Action 4.1.2:** Identify alternative evacuation and access routes in an emergency event. **Action 4.1.3:** Calculate and allocate funds for construction and implementation of additional essential emergency management services and facilities in low risk areas. **Action 4.1.4:** Establish a staging process to implement redundancy and back-up for essential emergency management services and facilities.

Program 4.2 Local government emergency management capacity: The emergency management capacity of local governments is improved.

Action 4.2.1: Provide local government emergency management personnel with greater access to information on climate change.
Action 4.2.2: Conduct emergency exercises (including recovery) based on worst case scenarios (includes use of best available science on CC), including consideration of multiple events, involving the community and all agencies to test out the emergency management arrangements under extreme cases.
Action 4.2.3: Identify limits to local government response capacity and support required from EMQ and/or other local councils.
Action 4.2.4: Increase budget available to local government emergency management units.
Action 4.2.5: Implement Qld's Disaster Management Warehouses and Caches Initiative to store stockpiles of emergency equipment.
Action 4.2.6: Establish information sharing and collaborative partnerships with community service providers to improve management of climate change risks and targeting of vulnerable populations.

Program 4.3 Communication between local councils: Improved and increased communication between emergency management personnel across local councils is facilitated.

Action 4.3.1: Establish an SEQ emergency management forum (e.g. Working group of the SEQ Council of Mayors) to encourage greater sharing of information and experience between local government emergency management personnel.

Program 4.4 Support our Heroes: Continue to implement Queensland's Support our Heroes Programme to strengthen the response capacity of SES and Rural Fire Service.

Action 4.4.1: Provision of greater incentives, recognition and training to volunteers.
Action 4.4.2: Provide additional equipment and resources to strengthen response capacity of SES and Rural Fire Service.

Policy 5. Stronger regional collaboration between local governments for emergency events is facilitated through a buddy system sponsored by the Council of Mayors (SEQ).

Program 5.1 Mutually supportive councils: Councils establish and maintain agreements with each other to provide assistance if required during an emergency event.

Action 5.1.1: Identify most appropriate process for this collaboration (e.g. Council to Council program, MoUs, Councils forming a joint board under the Local Government Act).
Action 5.1.2: Review State Disaster Management Arrangements to recognise, include and support this assistance system between local governments.

Policy 6. A series of programs facilitated by emergency management agencies to more effectively support the role of communities in disaster response and recovery to promote greater community resilience to extreme weather events and climate change.
Program 6.1 Community training programs: Community training programs in response and recovery are developed for community groups. **Action 6.1.1:** Work with community to identify key community groups to train in disaster response and recovery. **Action 6.1.2:** Provide ongoing disaster response and recovery training to identified community groups.
Program 6.2 Community Leadership: Community leadership during and after disasters is supported to promote improved disaster response and recovery. **Action 6.2.1:** Work with the community to identify key contact points within communities to ensure improved communication between community and emergency services during and after a disaster, especially if community is isolated. **Action 6.2.2:** Work with the community to identify and/or establish community group(s) responsible for disaster response and recovery within the community. **Action 6.2.3:** Investigate whether an amendment of the DM Act 2003 would be required to allow for nominated community groups to have a role in disaster response and recovery activities. **Sub-action:** State Disaster Management Plan and Local Government Disaster Management Plans to align with this amendment and recognise new disaster response and recovery role played by these nominated community groups. **Action 6.2.4:** Identify, record and integrate community disaster response and recovery groups into local disaster management plans. **Action 6.2.5:** Investigate whether community leadership during disaster response and recovery should be encouraged for all communities or only those isolated during and after disasters.

HUMAN HEALTH

D5: Human Health Adaptation Options

(refer to Section 5 of the Supplementary Report for a full description of Policies, Program, Action and Implementation recommendations)

Overarching Goal: To establish adaptation strategies to minimise vulnerability of SEQ residents to adverse human health impacts associated with climate change.

Key words: human health, adaptive capacity, risk communication, preparedness, heat wave, mental health, community resilience, volunteers, surveillance & monitoring

KEY: Public health role (see Table 11)

Policy 1. Responses to human health impacts of extreme weather events and projected changes in climate should be enhanced through strengthened and expanded health initiatives and emergency preparedness.

4. Develop

8. Evaluate

Program 1.1 Service Continuity in Disaster: Emergency Preparedness and Continuity Management assists health facilities to cope with changing risk profiles as a result of climate change.

Program 1.2 Heat wave management: Heat wave management and response is improved to minimise health risks during hot weather events.

Program 1.3 Psychosocial Support: Mental health and psychosocial support is enhanced through working with vulnerable communities.

Policy 2. Health risk minimisation and capacity building for communities, private sector and government departments should be assisted through a range of initiatives and programs.

3. Inform etc

5. Mobilise

6. Link

7. Ensure

8. Evaluate

Program 2.1 Community capacity-building: Capacity to adapt to health impacts is enhanced through identifying and supporting social networks.

Program 2.2 Community risk awareness: Health risk management is facilitated through communication and community awareness initiatives.

Program 2.3 Supporting Volunteers: volunteer retention and volunteer capacity to respond to health impacts and risks associated with climate change is improved through volunteer management and training.

Program 2.4 Improved availability of information: Improved availability of information for health authorities, professionals, private sector and other decision makers assists their capacity to adapt to climate change-related health hazards.

Program 2.5 Leadership development through collaboration: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Policy 3. Integration of health initiatives with policies and plans in other sectors to enhance climate adaptation efforts for human health.

6. Link

8. Evaluate

Program 3.1 Integration with Emergency Management: More integrated actions with Emergency Management assists the delivery of health services for frontline emergency health personnel and vulnerable groups that are susceptible to climate change health impacts.

Program 3.2 Integration with Urban Planning and Management: Integration of human health into urban planning and management increases resilience and reduces susceptibility to adverse health impacts of climate change.

Program 3.3 Integration with Physical Infrastructure: The vulnerability of communities and health services to climate change is minimised by further integrating human health considerations in the planning and management of physical infrastructure.

Policy 4. Surveillance & Monitoring for human health should be strengthened in order to have timely responses to future climate impacts.

1. Monitor

2. Diagnose

8. Evaluate

9. Research

Program 4.1 Improved understanding: Research, surveillance and monitoring leads to improved understanding of relationships between population health and climate change and capacity to respond to future health risks.

Program 4.2 Risk management and population health: Surveillance and monitoring allows for continuous improvement in risk management at a population health level.

Figure D5.1: **Human Health Adaptation Options Framework**

Policy 1. Responses to human health impacts of extreme weather events and projected changes in climate should be enhanced through strengthened and expanded health initiatives and emergency preparedness.
Program 1.1 Service Continuity in Disaster: Emergency Preparedness and Continuity Management assists health facilities to cope with changing risk profiles as a result of climate change **Action 1.1.1:** Use best available science on climate projections to evaluate natural hazards (flood risk, heat wave risk, bushfire risk), possible spatial distribution of risks and vulnerability, and develop hypothetical worst case scenarios of surges in demand for health services and assess the capacity of those services. **Action 1.1.2:** Continue to explore triage measures to reduce demand surges in hospitals or other essential/critical health facilities during extreme weather events. (For example, through treatment in public cool spaces or evacuation centres, and house visits or phone calls to vulnerable individuals). **Action 1.1.3:** Include assessment of climate change threats to health facilities (e.g. increasing frequency of extreme weather events and drought) in environmental analyses of Emergency Preparedness and Continuity Management plans and Business Continuity Plans, using best available science and mapping of climate change exposures. **Action 1.1.4:** Continue to ensure essential health facilities have multiple sources of power and communications; water storage; contingency plans, and independent critical services to complement their Emergency Preparedness and Continuity Management plans. **Action 1.1.5:** Make amendments to the Quality of Care Principles in the Aged Care Act 1997 for stronger requirements for aged care facilities to prepare emergency preparedness and business continuity plans for flood, cyclone, storms and bushfires.
Program 1.2 Heat wave management: Heat wave management and response is improved to minimise health risks during hot weather events. **Action 1.2.1:** Use thermal imaging and best available regional climate projections to assess spatial vulnerability (including social vulnerability and adaptive capacity) to current and future heat wave hazards. **Action 1.2.2:** Ensure heat wave management plans (or sub-plans) are incorporated in Local Disaster Management Plans and required through Local Disaster Management Guidelines. **Action 1.2.3:** Ensure Local Disaster Management Group members tasked with heat wave response have access to relevant organisations (such as the Red Cross) that coordinate periodically updated registers of contact details of vulnerable individuals. **Action 1.2.4:** Continue to check the health of vulnerable individuals during heat waves through house visits, buddy systems or phone calls as part of a scheme to ensure the health of vulnerable individuals is monitored during heat waves. **Action 1.2.5:** Ensure transport is provided for vulnerable individuals and/or neighbourhoods to public cool spaces during hot weather events. **Action 1.2.6:** Enhance the SEQ Heatwave Response Plan, for instance through: - Including measures to identify, locate, and communicate with groups vulnerable to heat events during and in preparation of heat waves; - Reviewing initiatives to promote awareness of health impacts of heat waves amongst vulnerable groups, and involving networks of vulnerable groups in heat wave response. This may involve carrying out interviews, focus groups, workshops or meetings with members of organisations that work closely with, or represent vulnerable groups;

- Ensuring that local government and other organisations involved in UHIE reduction, transport planning, and the mapping of areas vulnerable to heat collaborate with organisations responsible for heat wave response planning at the regional level, to assist in targeting heat stress prevention initiatives; and
- Ensuring that critical infrastructure operators receive alerts through heat wave early warning systems.

Action 1.2.7: Ensure heat event risks are considered in capital and operational planning and management for transport and electricity infrastructure.
Action 1.2.8: Reduce heat wave health risks associated with electricity grid failure through energy demand management initiatives and diversified power sources.
Action 1.2.9: Establish heat exposure thresholds for working environments to inform safety standards, accompanied by measures to ensure compliance.
Action 1.2.10: Ensure that procurement of workplace protective clothing and policies for their adoption accommodate thermal comfort to avoid worker heat stress and reduction in work capacity in hot environments.

Program 1.3 Psychosocial Support: Mental health and psychosocial support is enhanced through working with vulnerable communities.

Action 1.3.1: Target mental health and psychosocial support initiatives to identified vulnerable populations and/or neighbourhoods.
Action 1.3.2: Increase funding for mental health support and psychosocial health initiatives in areas where mental health services are under-resourced and where the mental health effects of climate change may become heightened.
Action 1.3.3: Provide additional financial counselling support, and psychosocial and mental health support to affected communities over the medium to long-term disaster recovery phase (up to 3 years or even more in some cases).
Action 1.3.4: Support early introduction of debriefing and counselling post-disaster, with follow-ups as required.
Action 1.3.5: Continue to work with social networks and community leaders to ensure their involvement enhances targeted and tailored mental health interventions (including preventive health interventions) for identified vulnerable populations and/or neighbourhoods.
Action: 1.3.6: Extend 'Skills for Psychological Recovery' training to social networks and community organisations in communities that are adversely affected by extreme weather events or considered vulnerable to climate change impact and ensure they have access to resources and information to increase community awareness of symptoms of mental health problems, and support for people experiencing mental health problems during disaster recovery.

Policy 2. Health risk minimisation and capacity building for communities, private sector and government departments should be assisted through a range of initiatives and programs.

Program 2.1 Community capacity-building: Capacity to adapt to health impacts is enhanced through identifying and supporting social networks.

Action 2.1.1: Assess the spatial distribution of vulnerability to natural hazards and climate change, and target community resilience initiatives to vulnerable areas.
Action 2.1.2: Work with health authorities, social networks and community organisations to ensure cohesion and consistency in their health messages

regarding climate-related health impacts.
Action 2.1.3: Identify current support networks for vulnerable groups and strengthen programs that build the capacity of community-based organisations and local level initiatives working with these groups to plan for future extreme weather events and associated health impacts.
Action 2.1.4: Local government continue to keep and regularly update a directory of community networks and organisations and liaise with these groups in matters relating to health impacts associated with climate change.
Action 2.1.5: Increase the adaptive capacity of social networks and community organisations by ensuring they have access to information and avenues for collaboration around climate adaptation for human health.
Action 2.1.6: Provide local case workers during disaster recovery to support people in mediating through multiple entitlements, social services and processes involved in their rebuilding and recovery. Case workers should work alongside and in collaboration with local government and state government departments involved in disaster recovery.
Action 2.1.7: Maintain social spaces and support for social gatherings that may contribute to community resilience to mental health impacts associated with extreme weather events and community capacity to organise around issues of health risk management relating to disaster prevention.

Program 2.2 Community risk awareness: Health risk management is facilitated through communication and community awareness initiatives.

Action 2.2.1: Strengthen intra and inter-organisational communication plans for health messaging regarding health impacts associated with climate change and extreme weather events to the public and vulnerable groups.
Action 2.2.2: Review communication methods for public health and safety messaging during disaster response and recovery. Include media providers in the development of communication plans to ensure important public health messages are prioritised in radio, television and local newspapers.
Action 2.2.3: Work with social networks and community organisations to ensure cohesion and consistency between social networks and health authorities in health messages relating to health risks associated with extreme weather events and climate change.
Action 2.2.4: Engage separately with different vulnerable groups to enhance understanding of their perceptions of risk, and identify appropriate tailored methods and content for health messaging and communications aimed at reducing health risks during extreme weather events.
Action 2.2.5: Provide information and resources to encourage public participation in initiatives for the prevention of health risks associated with climate change. This may involve initiatives such as:

- Health campaigns or provision of grey water reuse devices to ensure grey water reuse does not impose health risks or environmental risks;
- Maintenance and strengthening of food handling awareness campaigns for hot weather and electricity supply disruption;
- Public awareness campaigns for monitoring of rainwater tanks and other forms of rainwater storage in general to reduce risks of vector borne disease;
- Public awareness campaigns for maintenance and monitoring of air-conditioners to reduce the risk of Legionnaire's disease;
- Campaigns to promote awareness among employers and workers of the hazards of working in hot environments, including recognition of heat-related illness symptoms and implementation of appropriate heat stress management measures that do not cause significant income loss for working people; and
- Early warning systems regarding smog alerts, dust storms (e.g. for asthma and sufferers of other respiratory problems), and high aeroallergen periods.

Action 2.2.6: Ensure that local authority and state government programs encouraging the use of rainwater tanks and water demand management are

implemented alongside initiatives aimed at reducing health risks associated with vector-borne diseases, grey water usage, water reuse and other potential adverse health outcomes.
Program 2.3 Supporting Volunteers: volunteer retention and volunteer capacity to respond to health impacts and risks associated with climate change is improved through volunteer management and training. **Action 2.3.1:** Periodically seek feedback and input from existing and past volunteers assisting emergency health and disaster recovery to guide future volunteer recruitment, recognition and retention initiatives. **Action 2.3.2:** Provide training opportunities where possible for volunteers assisting health services during disaster recovery to increase incentives for ongoing volunteering. Types of training provided should simultaneously enhance volunteer roles and volunteer satisfaction and retention, and should relate to volunteer feedback and input. **Action 2.3.3:** Provide first aid training in vulnerable areas to increase the value of volunteer efforts. This includes training for special needs of vulnerable and disabled people during times of disaster. **Action 2.3.4:** Review efforts for health protection and health prevention for volunteers and frontline recovery workers during disaster recovery. **Action 2.3.5:** Establish a volunteering service to assist general practitioners and other health professionals wishing to volunteer their skills during times of disaster. **Action 2.3.6:** Ensure continued adequate resourcing of volunteer-based organisations assisting or ancillary to emergency health services and preventative health services.
Program 2.4 Improved availability of information: Improved availability of information for health authorities, professionals, private sector and other decision-makers to assist their capacity to adapt to climate change-related health hazards. **Action 2.4.1:** Identify priority health risks for SEQ associated with climate change impacts and differential vulnerability between populations, and share this information with various health authorities. **Action 2.4.2:** Ensure suitable information resources and collaborative links between Queensland, BoM, research institutions, and other sectors and industries affecting determinants of health to enhance the capacity of health authorities to recognise and respond to health risks associated with climate change in the region. **Action 2.4.3:** Develop a regional Health Decision Support System based on mapping of community health profiles, social and environmental determinants of health, infrastructure, health-related services and facilities, exposure to climate change impacts, and environmental features that increase health risks associated with climate change. Ensure that community representatives are able to give contextual input to the development and maintenance of Health Decision Support Systems, and that government and non-government organisations, private sector, and community groups have access to this system[7].

[7] This Health Decision Support System may incorporate information from climate change vulnerability assessments and resemble the HDSS developed by the Logan Beaudesert Health Coalition

Action 2.4.4: Provide Early Warning Systems (for events such as dust storms and extreme weather events) for aged care facilities and facilities housing people with disabilities, with appropriate methods of alert for people with hearing or vision impairments.
Action 2.4.5: Provide training on health impacts of climate change for current and future health professionals. This can be implemented through:

- Addition of climate change to undergraduate medical curricula;
- General Practitioner registrar training; and
- Continued Professional Development programs for Environmental Health Officers and other health professionals.

Program 2.5 Leadership development through collaboration: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.

Action 2.5.1: Strengthen public health input into existing water policy, regulation and surveillance infrastructure in order to reduce potential health risks associated with water scarcity and waterborne infections in recreational waters
Action 2.5.2: Ensure databases related to health impacts associated with climate change are accessible and shared across health departments of local government, Queensland Health, and other relevant organisations where possible to facilitate improved understandings of risks
Action 2.5.3: Establish a coalition/network for health professionals, industry bodies, non-government organisations and government agencies interested in issues of human health and climate change.

Policy 3. Integration of health initiatives with policies and plans in other sectors to enhance climate adaptation efforts for human health.

Program 3.1 Integration with Emergency Management: More integrated actions with Emergency Management assists the delivery of health services for frontline emergency health personnel and vulnerable groups that are susceptible to climate change health impacts.

Action 3.1.1: Improve health messaging during disaster preparedness and recovery through increased integration with emergency management communications.
Action 3.1.2: Provide emotional support and counselling to protect the wellbeing of health and emergency response staff that are both disaster victims as well as key workers required for emergency response.
Action 3.1.3: Continue to link Emergency Preparedness measures of health facilities and services with Early Warning Systems and seasonal forecasts of extreme weather events.
Action 3.1.4: Ensure Local Disaster Management Groups have access to organisations coordinating periodically updated registers of contact details of people with chronic health conditions and other vulnerable individuals (such as the Red Cross, or other relevant organisation).
Action 3.1.5: Volunteer and/or paid staff tasked with running evacuation centres are given food safety guidelines, and training is offered to ensure at least one food safety supervisor with appropriate competency standards is present at evacuation centres.
Action 3.1.6: Ensure aged care organisations (residential care, retirement villages and community care) play an active role in local government disaster

management planning, and have representatives on Local Disaster Management Groups.
Action 3.1.7: Ensure that evacuation centres are equipped with appropriate facilities and supplies required to meet the needs of people with disabilities and vulnerable older people, (such as accessible toilets and showers, privacy screens and suitable bedding).
Action 3.1.8: Include community resilience and health prevention considerations in long-term post-disaster recovery plans and disaster mitigation plans.

Program 3.2 Integration with Urban Planning and Management: Integration of human health into urban planning and management increases resilience and reduces susceptibility to adverse health impacts of climate change.

Action 3.2.1: Strategically relocate/retreat and/or upgrade essential health facilities to ensure appropriate standards for building design, backup of and siting of essential infrastructure. This may involve strategic relocation and/or upgrade of health services and facilities into low risk areas so they can continue to operate during emergencies.
Action 3.2.2: Ensure climate change vulnerability assessments and mapping contribute to reviews of Emergency Preparedness and Continuity Management plans to prepare health facilities in areas with elevated risks are prepared for disruption in infrastructure from natural hazards.
Action 3.2.3: Ensure transport planning provides access to health services, evacuation centres, and public cool spaces, prioritising neighbourhoods whose residents are more likely to have limited access to private transport and limited transport options.
Action 3.2.4: Encourage active and sustainable transport through urban design.
Action 3.2.5: Encourage innovative urban planning and design to minimise communities' exposure to extreme heat events and urban heat island effect (UHIE) through improved parkland design guidelines, and building design and performance standards that improve indoor thermal comfort and reduce energy demand.
Action 3.2.6: Develop and carry out urban forestry and tree planting programs, and tree protection bylaws to reduce UHIE and sun exposure. This may include grants and resources for community-based tree planting and urban greening initiatives that reduce UHIE and sun exposure.
Action 3.2.7: Continue to encourage active and sustainable transport through health campaigns and infrastructure provision.
Action 3.2.8: Improve parkland design guidelines to encourage reduced UHIE, and facilitate physical activity and active transport.
Action 3.2.9: Implement environmental/landuse interventions to maximise local food security and minimise adverse impacts of climate change on accessibility to affordable local food and nutrition. This may include actions such as:

- Identifying and amending local government bylaws and/or local laws and town planning scheme attributes that may unintentionally deter urban food production;
- Integrating food production into urban design and parkland design guidelines; and
- Provision of resources in open space planning to facilitate local food security (such as resources for edible planting, city farms and farmers markets).

Program 3.3 Integration with Physical Infrastructure: The vulnerability of communities and health services to climate change is minimised by integrating human health considerations in the planning and management of physical infrastructure.

Action 3.3.1: Ensure health facility Emergency Preparedness and Continuity Management plans and associated redundancy plans are matched with multiple sources of power, water storage, communications, and contingency plans in the event of blocked access routes and/or disrupted infrastructure.
Action 3.3.2: Reduce heat wave health risks associated with electricity grid failure by diversifying and decentralising power sources, and improving

demand management during heat wave events.
Action 3.3.3: Evaluate water sanitation infrastructure in the context of increased health risk from flood/drought, and incorporate this information into infrastructure planning, water management, and disaster preparedness measures for health protection.
Action 3.3.4: Ensure monitoring of sanitation infrastructure during disaster to prevent and/or manage health risks and hazards, and promptly trigger communication plans for public health messages.

Policy 4. Surveillance & Monitoring for human health should be strengthened in order to have timely responses to future climate impacts.
Program 4.1 Improved understanding: Research, surveillance and monitoring leads to improved understanding of relationships between population health and climate change and capacity to respond to future health risks. **Action 4.1.1:** Support research to increase understanding of impacts of climate change on the health of different communities. This may include analysis of hospital admissions and doctor visits, laboratory reports, excess deaths, sentinel records, and epidemiological data in relation to climate phenomena. Research could also include investigation into the impacts of climate change on social determinants of health. **Action 4.1.2:** Combine epidemiological surveys and studies of epidemiological, environmental and social determinants of health in a comprehensive Risk Assessment Surveillance System (RASS) to guide public health interventions for climate change adaptation. **Action 4.1.3:** Research the relationship between air pollutants and climate parameters, and potential health risks under projected population increases and changes in climate for metropolitan areas of SEQ[8]. **Action 4.1.4:** Research health implications of sea level rise, storm surges and changing rainfall patterns with regard to algae and water contamination in recreational waters, and mosquito breeding habitats.
Program 4.2 Risk management and population health: Surveillance and monitoring allows for continuous improvement in risk management at a population health level. **Action 4.2.1:** Periodically assess and update health surveillance systems and health alert systems with best available science and knowledge of links between climate and health to ensure that they are capable of detecting and responding to changes in disease patterns that may result from climate change. **Action 4.2.2:** Expand environmental health and health equity programs to ensure they include newly identified at-risk areas. **Action 4.2.3:** Identify and develop indicators to monitor climate change-related health outcomes within health surveillance systems and health alert systems. **Action 4.2.4:** Incorporate social indicators of health and health equity in systems of surveillance and monitoring for climate change adaptation for human health.

[8] This could include incorporate considerations of health risks of increased particulate matter following dust storms and/or bushfires as well as from industrial air pollutants.

APPENDIX E: PRIORITISATION OF ADAPTATION OPTIONS - TRIAL RESULTS

E1: Multi-Criteria Analyses (including Analytic Hierarchy Process)

Introduction

The selection and implementation of appropriate adaptation options and strategies to reduce climate change impacts is a complex problem. The process of prioritisation and selection of adaptations must involve stakeholders so that the process of implementation can be facilitated successfully.

This research project has identified and evaluated a range of preferred adaptation options (specifically Actions) which could reduce vulnerability to a changing climate. This trial has applied multi-criteria analyses (MCA) to explore stakeholders' opinions for adaptation actions to adapt to the impacts of climate change.

Through a survey questionnaire, five adaptation options were explored to obtain the opinions of stakeholders. For multi-criteria analyses, the Analytic Hierarchy Process (AHP) technique was employed. AHP is a method designed to help in prioritising very complex decision alternatives involving multiple stakeholders and multiple goals. Pair-wise comparisons are the fundamental buildings blocks of AHP.

By using the questionnaire, the participants compared the relative importance of the decision alternatives of pair-wise with respect to criteria and the goal explained below (Figure E1).

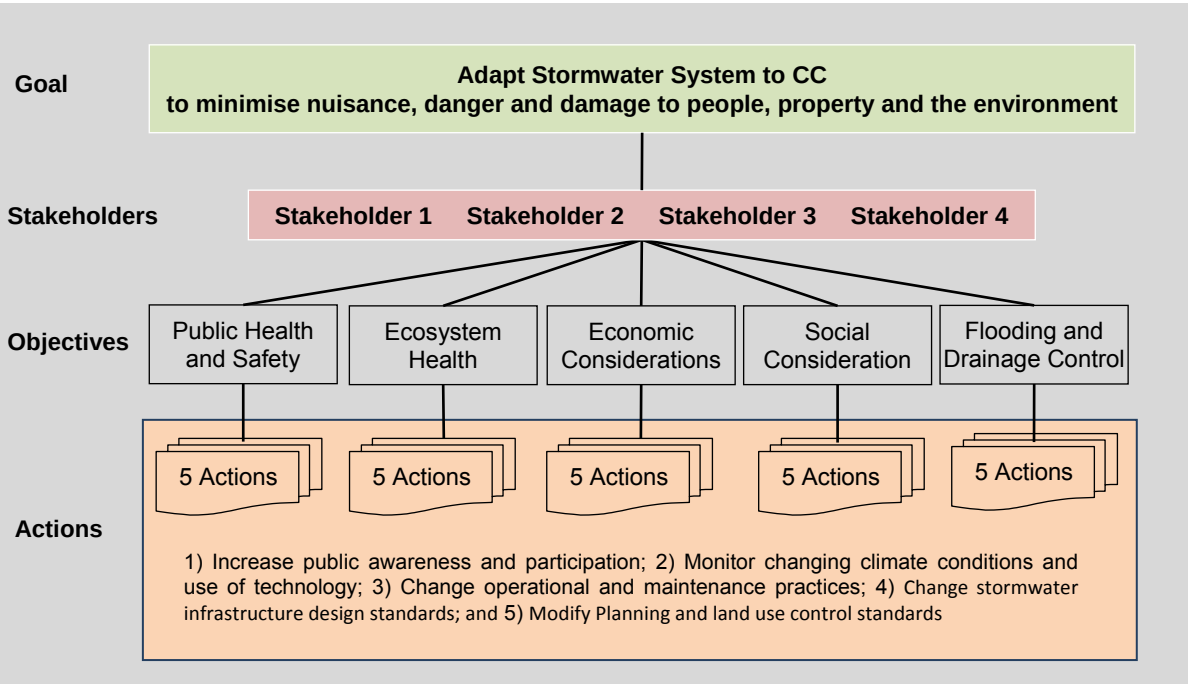


Figure E1: Analytical Hierarchy of Decision Making Process

Each participant was requested to enter their judgements and make a distinct, identifiable contribution to the issue. Participants do not have to agree on the relative importance of the criteria or the rankings of the alternatives.

As illustrated in Figure E1; the first level of hierarchy is the ultimate goal of the project; the second level includes the stakeholders who take part in decision making on stormwater systems; the third level represents the criteria on the basis of which the actions are to be evaluated and, finally, the fourth level presents the adaptation actions.

Goal: *To adapt stormwater systems to climate change in order to minimise nuisance, danger and damage to people, property and the environment*.

Stakeholders: The stakeholders, who are involved in the decision making process were identified. This trial mainly targeted agencies and departments that prepare stormwater management plan within local government (i.e. engineering services, planning and environment, water services etc.) and excluded other possible stakeholders such as residents, businesses and the like.

Objectives: The objectives of each stakeholder were then identified and included in the decision hierarchy, shown in Figure E1. Based on the multiple objectives outlined in ARMCANZ and ANZECC (2000), this trial used the following five criteria for stormwater management for MCDA analyses and finalisation after consulting the stakeholders:

1. *Public health and safety:* to minimise the risk to public health from mosquitoes, to the community/properties from flooding, and of injury or loss of life;
2. *Ecosystem health:* to retain natural drainage systems, and protect ecosystem health and protect existing values of waterways, wetlands, estuaries, marine and associated vegetation from development impacts;
3. *Economic considerations:* to implement stormwater management systems which are economically viable in the long-term. In many cases, the perceived cost of alternative stormwater treatment systems results in reluctance to change. However, in reality or when demonstrated, the long-term costs may be significantly lower than conventional systems. In addition, the value of stormwater in the built environment is taken into account and reflects its true social, environmental and economic contributions;
4. *Social considerations (eg aesthetic values – recreational opportunities):* to ensure that community social, aesthetic and cultural values are recognised and maintained when managing stormwater. Community values now encompass concern for improved access to open space and a variety of recreation opportunities, quality of life, and aesthetic living environment, conservation of Aboriginal heritage sites, environmental protection and ecologically sustainable development; and
5. *Flooding and drainage control:* to protect the built environment from flooding and waterlogging. It is important to ensure that urban environments have minimal risk of damage from water.

Actions: The following five adaptation actions for stormwater management were derived, and based upon, adaptation programs, existing adaptation works by local and federal governments, and an extensive literature review (ARMCANZ and

ANZECC, 2000, DWSRT, 2007, TRCA, 2009, Taylor, 2005, DNRW, 2008, DEFRA, 2011b, EEA, 2011):

1. *Increase public awareness and participation* (Action 2.2.2)[9]: Develop public education and awareness programs concerning the negative impacts of climate change on stormwater infrastructure;
2. *Monitor changing climate conditions and use of technology* (Action 2.2.4): Monitor conditions of stormwater infrastructure conditions through greater use of technology to receive advance warnings, and use alternative preventive retrofitting or reconstruction to reduce the impact of changing climate;
3. *Change operational and maintenance practices* (Action 2.1.1): Incorporate climate change in emergency planning by considering potential increases in frequency of flooding. Use more proactive operational and maintenance standards by redesigning or improving existing standards to withstand the new conditions due to climate change and associated extremes;
4. *Change stormwater infrastructure design standards* (Action 2.1.2): Modify stormwater management infrastructure design standards to increase capacity in anticipation of increased stresses due to climate change. Many stormwater infrastructures are currently designed for the 1 in 100 year flood event. However, it is predicted that what is today's 100-year flood event from precipitation is likely to occur more frequently (i.e. every 50 or even every 20 years by the end of the century). Therefore it is important to understand whether current design standards are sufficient to accommodate climate change; and
5. *Modify Planning and land use control standards* (Actions 2.1.6 & 3.2.10): To prevent or reduce development in flood prone areas in anticipation of increased frequency and magnitude of flooding due to changing climate, modify land use regulations and development standards to avoid placing people and new developments in vulnerable locations, and relocate existing vulnerable infrastructure and communities gradually to safer areas.

Method

Table E1 provides a brief summary of the different types of tools and techniques that can be used at various levels of the decision making process (Willows & Connell, 2003). Whilst this table is not comprehensive, it does provide a listing of the more popular methods that were considered for use within the decision making framework. Table E2 provides an elaboration of Stage 5—Evaluate Alternatives—to showcase the many types of decision analysis tools that were considered for use in the ranking of adaptation alternatives.

[9] Equivalent Action from PI sector's adaptation options indicated.

Table E1: Suitability of various tools in the six stages of decision making (adopted methods highlighted in blue)

	Stages of Decision Making Framework					
Tools and Techniques	**1. Identify the problem**	**2. Identify stakeholders and determine objectives (criteria)**	**3. Risk assessment**	**4. Identify adaptation alternatives**	**5. Evaluate alternatives**	**6. Make Decision**
AIDA[l]	✓	✓		✓		
Brainstorming (SEQ CARI)	✓	✓	✓	✓		
Consultation (stakeholders)	✓	✓	✓	✓	✓	✓
Focus groups	✓	✓		✓	✓	
Case study analysis		✓	✓	✓		
Literature review		✓	✓	✓		
Individual expert judgement			✓			
Climate typing			✓			
Cross-impact analysis			✓		✓	
Deliberate imprecision			✓			✓
Downscaling techniques			✓			
Interval analysis			✓			
Modelling tools			✓			
Pedigree analysis			✓			✓
Process influence diagrams			✓			
Scenarios analysis			✓		✓	
Uncertainty radial charts			✓			
Screening				✓	✓	
Contingent valuation					✓	
Cost-effectiveness analysis					✓	
Cost-benefit analysis					✓	
Decision analysis					✓	
Decision conferencing					✓	
Discounting					✓	
Environmental impact assessment					✓	
Expected value					✓	✓

	Stages of Decision Making Framework					
Tools and Techniques	**1. Identify the problem**	**2. Identify stakeholders and determine objectives (criteria)**	**3. Risk assessment**	**4. Identify adaptation alternatives**	**5. Evaluate alternatives**	**6. Make Decision**
Financial analysis					✓	
Fixed rule-based fuzzy logic					✓	
Minimax, Maximin, Maximax and Regret					✓	✓
Multi-criteria analysis (scoring and weighting)					✓	
Pairwise comparison					✓	
Partial cost-benefit analysis					✓	
Preference scales					✓	
Ranking/dominance analysis					✓	
Risk-risk analysis					✓	
Sieve mapping					✓	
Hedging and flexing						✓
Portfolio analysis						✓
Sensitivity analysis						✓
Robustness analysis						✓
Ranges and intervals						✓

Table E2: Methods available for evaluating adaptation alternatives (adopted methods highlighted in blue)

Tools and Techniques	**Qualitative methods**	**Alternative methods**	**Quantitative and economic based methods**	**Complexity** L: low, M:med, H:high	**Data Required** L: low, M:med, H:high
Multi-criteria analysis (scoring and weighting)			✓	M	M

Pairwise comparison	✓			L	M
Consultation (stakeholders)	✓			M	M
Focus groups	✓			M	M
Cross-impact analysis	✓			M	M
Scenarios analysis	✓	✓	✓	M	M
Screening		✓		L	M
Contingent valuation		✓	✓	H	H
Cost-effectiveness analysis			✓	L	M
Cost-benefit analysis			✓	H	H
Decision analysis			✓	H	H
Decision conferencing			✓	H	H
Discounting			✓	L	H
Environmental impact assessment		✓		H	H
Expected value			✓	M	H
Financial analysis			✓	M	M
Fixed rule-based fuzzy logic	✓	✓	✓	H	M
Minimax, Maximin, Maximax, Regret				M	M
Partial cost-benefit analysis	✓		✓	H	M
Preference scales	✓			M	L
Ranking/dominance analysis	✓			L	M
Risk-risk analysis		✓		M	M
Sieve mapping	✓			H	H
Policy Exercise	✓			M	M

Sources: (UKCIP 2003) and AIDA: Analysis of Interconnected Decision Areas

Results

In order to elicit a priority ranking of the adaptation actions, the stakeholder participants were asked to make pairwise comparisons on the action alternatives with respect to the goal of 'Adapting Stormwater Systems to Climate Change'

Trial Stakeholder Survey

Stakeholders: 1) Engineering; 2) Planning; and 3) Finance [Departments of Sunshine Coast Regional Council (SCRC), Moreton Bay regional Council (MBRC), and Gold Coast City Council (GCCC)]

Criteria: 1) Public Health and Safety; 2) Ecosystem Health; 3) Economic Considerations; 4) Social Considerations; and 5) Flooding and Drainage Control

Adaptation Actions: 1) Increase public awareness and participation; 2) Monitor changing climate conditions and use of technology; 3) Change operational and maintenance practices; 4) Change stormwater infrastructure design standards; and 5) Modify Planning and land use control standards.

Consistency Ratio (CR)

The results were first checked for consistency to ensure their validity in terms of their consistency (i.e. holding an unchanged opinion over the period of the activity). Although the AHP does not demand perfect consistency to elicit a rank of alternatives, there is a threshold of CR<10%; for environmental problems that pose high variability. Saaty et al (1991) and Saaty and Kearns (1985) suggest that a CR<20% is acceptable. A review of the trial results revealed CRs for SCRC of 5.4%, MBRC of 1.4%, and for GCCC of 3.2% - suggesting that the data is well within the acceptable level.

Data Analysis

Prioritisation of Stakeholders

Combining the judgements made by all participants, it was found that the most important stakeholder group in the decision making process was *Planning.* The second and third most important stakeholder groups were considered to be *Engineering* and *Finance* respectively. This ranking priority was however not displayed when using the judgements made by separate stakeholder groups. It was found that in all cases each stakeholder group did not assign themselves with the most importance and in the case of *Finance* department, they assigned themselves with by far the least importance. This could infer that each stakeholder does not necessarily hold themselves with the highest importance. Furthermore, it could be concluded that each stakeholder group either feels as though they don't have as much input as they actually do, or they do not want the greatest responsibility in the decision making process. Considering this observation, it was important to structure a hierarchy model that will use a combined participant judgment to assign the weight of each stakeholder group.

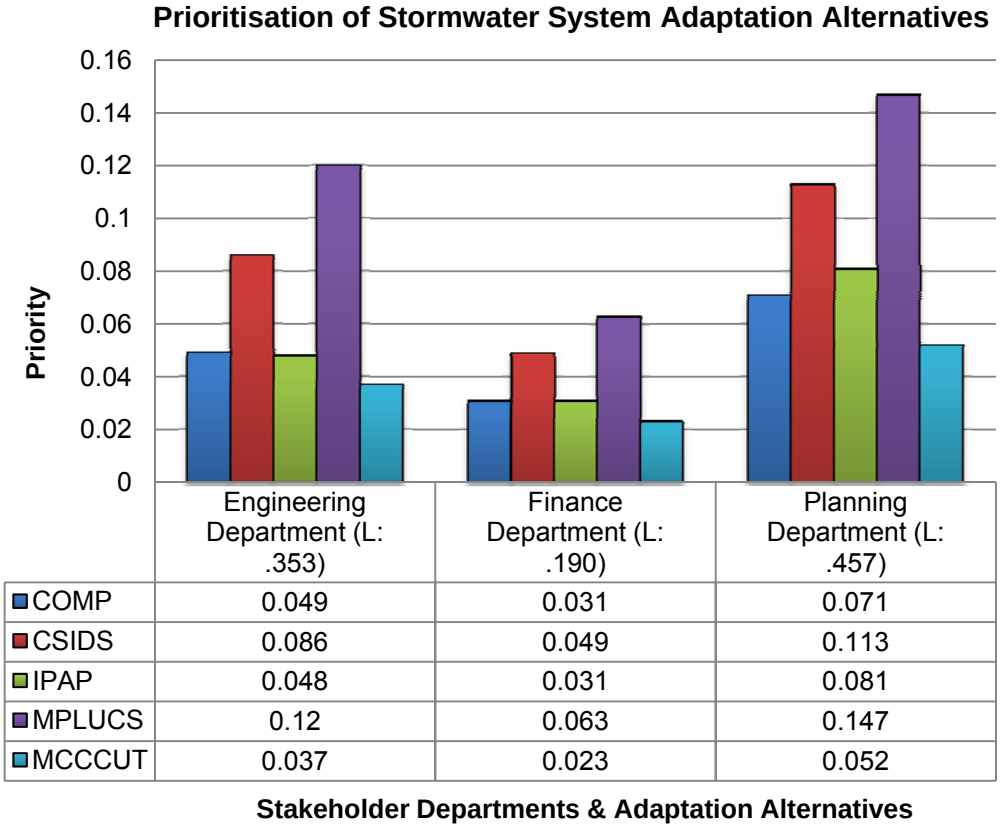
Prioritisation of Criteria

Combining the judgements made by all participants, it was found that the most important criteria to consider when comparing the five adaptation alternatives is *Public Health and Safety* closely followed by *Economic Considerations* (Figure E2). This priority ranking however was not reflected by any of the individual stakeholder groups which further exemplify the diverse opinions and the need for MCDA. The least preferred criterion was *Social Considerations* which was a general trend for all three stakeholder groups.

It could be expected that *Public Health and Safety* would gain the highest priority due to the endangerments recently experienced in the 2011 SEQ floods. It could also be expected that *Economic Considerations* would closely follow due to the participant's knowledge of the economic pressure associated with floods, especially flood recovery, combined with the current poor economy. Whilst this was strongly the view of the *Engineering* department and marginally the case with respect to the opinion of all participants, what is interesting was the views of both the *Finance* and *Planning* departments who favoured *Economic Considerations* over *Public Health and Safety*. Possible reasoning could point to the current media hype surrounding the global financial crisis and/or both groups do not consider the issue of climate change and stormwater system vulnerability to be of concern. This therefore suggests that when making a final decision, decision-makers must take into account the current social

conditions and consequent media hype that may greatly affect the participant's judgment.

A noticeable trend can be seen when comparing the two lowest preferred criteria; respectively *Ecosystem Health* and *Social Considerations*. It was observed that for both the combined stakeholder opinion as well as the individual stakeholder opinions, *Ecosystem Health* was considered more important than *Social Consideration*; although not by much. This could suggest that participants are well aware of the environmental threats associated with inadequate stormwater systems such as flooding and droughts, and do not consider social considerations such as aesthetic and recreational values as important. It would be interesting to ascertain if the general public held this opinion.



COMP: Change Operational and Maintenance Practices; CSIDS: Change Stormwater Infrastructure Design Standards; IPAP; Increase Public Awareness and Participation; MPLUCS; Modify Planning and Land Use Control Standards; MCCCUT: Monitor Changing Climate Conditions and Use of Technology

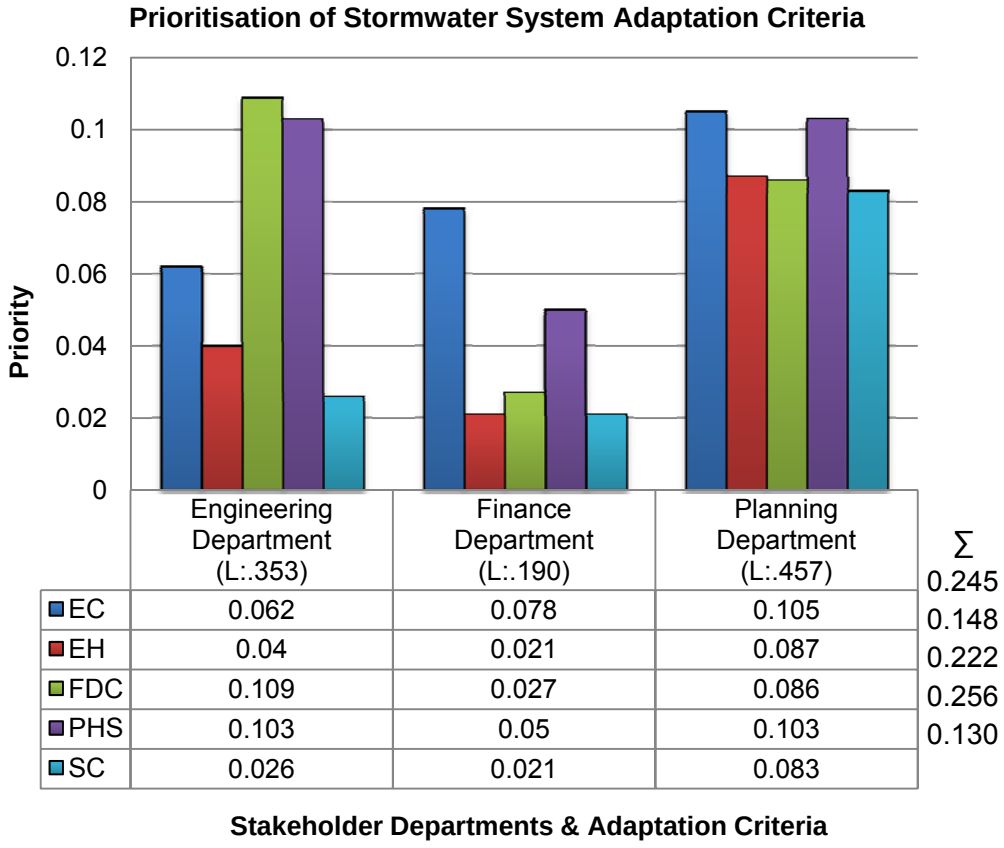
Figure E2: Criteria priorities with respect to each stakeholder group

The aforementioned priorities were elicited through using the judgements made by all participants. It was found that using the judgements made by each stakeholder group separately, resulted in a priority ranking that differed from the ranking expressed in Figure E2. This suggests that allowing stakeholders to make judgements on what they perceive to be the opinion of another stakeholder group is inaccurate. Similarly, it was found that when using the judgements made by each local authority separately, the priority ranking differed from the ranking presented in

Figure E2. This suggests that each local authority has differing opinions based on their regional conditions (i.e. funding, adaptation capacity etc.).

Prioritisation of Alternatives

Using the combined stakeholder judgement, it was found that the most preferred adaptation alternative was *Modify Planning and Land Use Control Standards*, followed by *Change Stormwater Infrastructure Design Standards (*Figure E3). These priorities are reflected in the individual stakeholder priorities which suggest a strong consensus on the prioritisation of these two alternatives. The reasons behind the stakeholder's first and second preferences are numerous, with one such reason being that due to the extensive infrastructure damage as a result of the January 2011 SEQ floods, it has become apparent that housing and infrastructure is built too close to natural flow paths.



EC: Economic Considerations; EH: Ecosystem Health; FDC: Flooding and Drainage Control; PHS: Public Health and Safety; SC: Social Considerations

Figure E3: Criteria priorities with respect to each stakeholder group

The least preferred alternative was *Monitor Changing Climate Conditions and Use of Technology* which again was a general trend across all three stakeholder groups. This result seems rather unusual due to the fact that there is a considerable amount of uncertainty when it comes to local-scale climate projections. Considering this uncertainty, it is even stranger that the *Finance* department too expressed this priority when there are huge costs associated with implementing climate adaptation strategies. This could possibly infer that end-use professionals entirely trust the

climate projections and are willing to bare the upfront costs in the chance that they are correct. Or another possible reason is that the participants involved did not fully understand this alternative and therefore neglected giving it priority.

A noticeable trend can be seen when comparing *Increase Public Awareness and Participation* and *Change Operational and Maintenance Practices*. Examining both the combined stakeholder ranking as well as the individual stakeholder ranking, the preference given to these two alternatives is very close. This seems appropriate as increasing public awareness of the vulnerability of stormwater system's to extreme events (e.g. blocked drains) can supplement the council's maintenance practices. Another interesting observation was that the *Finance* department held the highest priority for the two most expensive options. This could suggest that no matter the department, it is a strong opinion that physical adaptation action needs to occur.

The aforementioned priorities were elicited through using the judgements made by all participants. It was found that using the judgements made by each stakeholder group separately, resulted in a priority ranking that differed from the ranking expressed in Figure E2. This suggests that allowing stakeholders to make judgements on what they perceive to be the opinion of another stakeholder group is inaccurate. Similarly, it was found that when using the judgements made by each local authority separately, the priority ranking differed from the ranking presented in Figure E2. This suggests that each local authority has differing opinion based on their regional conditions (i.e. funding, adaptation capacity etc.).

Conclusion

It was observed that the prioritisation of adaptation criteria and alternatives varied noticeably between using the judgement of combined participants compared to using the judgements of each stakeholder groups. This therefore suggests that although there is an acceptable level of consistency within the results used, there exists some disparity between the stakeholders opinion on:

1) The importance or ranking of each stakeholder in the decision making process; and
2) What each stakeholder group believes to be the opinion or preference of each other stakeholder group.

When looking at the ranking of alternatives according to the judgments made by each stakeholder group, it was interesting to observe that in most cases the priorities expressed by each stakeholder were then assumed to be the priority for the other two stakeholder groups; although the strengths of preference were not the same. This exemplifies the proposition that allowing stakeholders to make judgements on what they perceive to be the opinion of another stakeholder group is inaccurate.

Another observed trend was the difference between the weights each stakeholder assigned themselves in comparison to the weight collectively assigned by the 'Combined Participant Judgement'. This could infer that each stakeholder does not necessarily hold themselves with the highest importance. In the case of the *Finance* department, they were found to hold themselves with the lowest opinion weight. Furthermore, it could be concluded that each stakeholder group either feels as

though they don't have as much input as they actually do, or they do not want the greatest responsibility in the decision making process. Considering this observation, it is important to structure a hierarchy model that will use a combined participant judgment to assign the weight of each stakeholder group.

Finally, it was noted that in all cases (combined participant judgement, each stakeholder groups, and individual local authorities) there was a clear distinction between the significantly higher prioritised alternatives and the remaining lower and less preferred options. This suggests that within individual stakeholder groups, as well as the combined opinion of all stakeholders, there is a clearly identified preference over two alternatives: *Modify Planning and Land Use Control Standards* and *Change Stormwater Infrastructure Design Standards.* The remaining three alternative were clustered together (similar priorities) and separated significantly from the two most preferred. This may imply that, although there are two clearly preferred alternatives, the participants are confused as to the implementation of the remaining alternatives. In the case of the most preferred options being unviable, or if there is a desire to implement multiple adaptation alternatives, this cluster could pose some negative consequences such as implementation delay.

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E2: Finite Element Analysis Techniques

This section presents an example of how engineering tools (specifically Finite Element Analysis) can be used to evaluate the performance of both rigid and flexible pavements under different climate change scenarios. The specific example addresses the Physical Infrastructure sector's actions for Program 1.1 (see PI Adaptation Options Framework – Appendix D3). The first step involved developing and validating three-dimensional finite element models of both concrete (rigid) and bituminous surfaced (flexible) against field data [References 1, 2, 3 & 6][10]. These models where then used to investigate the impacts of future climate conditions on road deterioration in SEQ by evaluating thermal cracking of rigid roads and moisture induced cracking of flexible roads [4,5]. Illustrated in Figure E4 is an example of the rigid road system model (Figure E4 top) and associated tensile stress contour when subject to an increase in ambient temperature (Figure E4 bottom). Data for changes in temperature and moisture was identified based on downscaled CSIRO climate projections.

[10] References refer to publication of research which is currently in progress

This research advanced the understanding of the complex road failure mechanisms when subject to changing temperature and moisture conditions. Note that some of these findings were presented at two seminars [7,8]. The relationship between the climate factor and pavement deterioration evaluated in this study will help state and local governments to better manage the road assets in light of climate change.

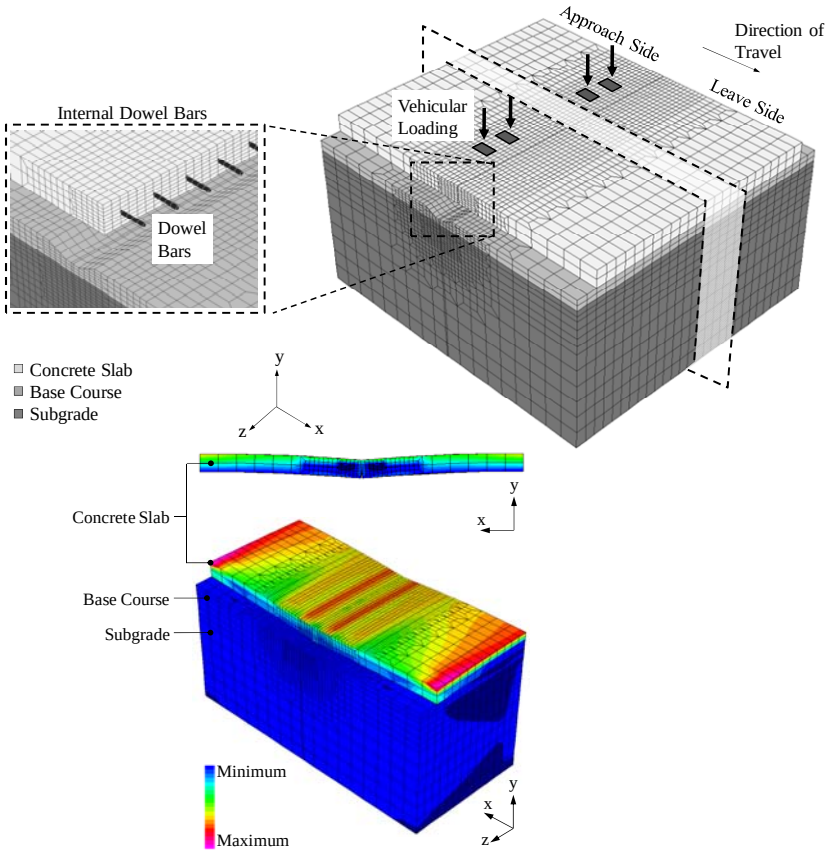

Figure E4: Evaluation of thermal road surface cracking under deteriorating climate conditions (SEQ)

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APPENDIX F: RELEVANCE OF SECTORAL ADAPTATION OPTIONS TO HUMAN SETTLEMENT TYPES & ADAPTATION THEMES

Statutory planning | Non-statutory planning | Non-statutory and/or statutory planning

Table F1: Relevance of Adaptation Policies & Programs to Human Settlement Types and SEQ Region

Policies[11]	Programs[12]	Coastal / Inland: *"Sandy Shores"* (beachfront high rise holiday destination)	*"Blue Waters"* (canal estate)	*"Greenhaven"* (middle suburb)	*"Aussie Downtown"* (Regional Activity Centre)	*"Alphaville"* (peri-urban community)	*"Utopia"* (master planned community)	SEQ (*"Lilliput"*) region (rapidly growing coastal metropolitan region)
Urban Planning and Management Sector								
Policy 1. The statutory and non-statutory planning processes must seek to minimise the vulnerability of coastal landscapes to storm tide and sea level rise inundation, coastal erosion, cyclones and severe winds, severe storms and hail, and flooding.	**Program 1.1 Consolidation of urban development:** Urban development is consolidated by favouring infill and redevelopment of existing urban areas to minimise the extent of development occurring in highly vulnerable coastal areas.			○	○			●
	Program 1.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.	●	●	○	○			●
	Program 1.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to coastal hazards.		●	○				●
	Program 1.4 Building code design criteria: Building codes are reviewed to incorporate design criteria for buildings to resist future loads that may result from the impact of climate change-exacerbated hazards during a minimum service life of 50 years.	●	●	○	○			●
	Program 1.5 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to reduce or eliminate damage caused by flooding as a result of sea level rise and coastal storm surge events.	●	●	○	○			●
	Program 1.6 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to receding shorelines are sited landward and/ or relocated.	●	●	○	○			●
	Program 1.7 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can operate during emergencies - consider threats to communications, transport and water infrastructure.	●	●	○	○			●
	Program 1.8 Coastal defence: Coastal defence mechanisms are implemented to provide continuing flood and erosion risk management due to storm tides and sea level rise	●	●	●	●			●
	Program 1.9 Hazards full disclosure clause: A Coastal Hazards Full Disclosure Law is implemented to alert buyers of coastal properties about current and future climate related risks such as erosion rates, storm history, inundation and sea level rise.	●	●	○	○			●
	Program 1.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, (Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water) are decentralised and/or equipped with back-up systems.				○			●
	Program 1.11 Innovative design for coastal areas: Innovative engineering and design solutions are employed to manage coastal hazards in low risk areas.	●	●	●	●			●
	Program 1.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises	●	●	○	○			●

[11] Some Policy descriptions are abridged – see Chapter 10 or Appendices D for full wording

[12] Some Program descriptions are abridged – see Chapter 10 or Appendices D for full wording

Policies[11]	Programs[12]	Coastal / Inland: **"Sandy Shores"** (beachfront high rise holiday destination)	**"Blue Waters"** (canal estate)	**"Greenhaven"** (middle suburb)	**"Aussie Downtown"** (Regional Activity Centre)	**"Alphaville"** (peri-urban community)	**"Utopia"** (master planned community)	**SEQ** (*"Lilliput"*) **region** (rapidly growing coastal metropolitan region)
	alterations to natural flow regimes, including floodplain connectivity.							
	Program 1.13 Protection of coastal habitats: Areas that provide for the landward retreat of coastal habitats and species at risk from predicted sea level rise are identified and protected.							●
	Program 1.14 Long-term (strategic) planning: Planning and decision-making consider the potential implications of climate change over the life of long-term assets (100 year planning horizon).	●	●	●	●			●
	Program 1.15 Coordinated response to sea level rise: A coordinated response to sea-level rise is initiated to develop measures related to coastal defence, accommodation and planned retreat.	●	●					●
	Program 1.16 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.	●	●	○	○			●
	Program 1.17 Coastal erosion risk minimisation: A coastal erosion preparedness and awareness scheme is initiated to minimise risks from coastal erosion, including climate change projections, in vulnerable areas.	●	●	●	●			●
	Program 1.18 Coastal inundation risk minimisation: A coastal inundation preparedness and awareness scheme is initiated to minimise coastal inundation risks, including climate change projections, in vulnerable areas.	●	●	●	●			●
	Program 1.19 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.	●	●	○	○			●
Policy 2. The statutory and non-statutory planning processes must seek to minimise the vulnerability of inland landscapes to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.	**Program 2.1 Consolidation of urban development:** Infill development is consolidated in existing urban areas while avoiding areas with high exposure to flooding and bushfire.			○	○	●	●	●
	Program 2.2 Infrastructure sites: Essential infrastructure sites and corridors are identified, protected and managed from climate change impacts.			○	○	●	●	●
	Program 2.3 Community planning: Residential accommodation, which is designed and located to integrate with the surrounding community, is provided to meet the specific needs of youth, the aged, people with disabilities and other disadvantaged groups to minimise their vulnerability to climate change impacts.			○		●		●
	Program 2.4 Building code design criteria for floods: Building codes are reviewed to ensure building structures withstand projected site-specific flood levels.			○	○	●	●	●
	Program 2.5 Building code design criteria for bushfire: Building codes are reviewed to ensure building structures are more resilient to bushfires.			●	●	●	●	●
	Program 2.6 Retrofitting of residential properties: A program to assist households to retrofit high risk homes is created to improve adaptation to heatwaves and high temperatures, flooding, severe storms and hail, and bushfires.			○	○	●		●
	Program 2.7 Planned retreat: Building structures, infrastructure and public facilities in areas adjacent to floodplains are sited landward and/ or relocated.			○	○	●		●
	Program 2.8 Strategic relocation and upgrade of essential emergency and health services: Emergency and health services are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks so they can operate during emergencies - consider threats to communications, transport and water infrastructure.			○	○	●		●
	Program 2.9 Hazards full disclosure clause: A Hazards Full Disclosure Law is implemented to alert buyers of properties about current and future climate related risks associated with flooding, including riverine and flash floods, and bushfire.			○	○	●	●	●

Policies[11]	Programs[12]	Coastal / Inland: "Sandy Shores" (beachfront high rise holiday destination)	"Blue Waters" (canal estate)	"Greenhaven" (middle suburb)	"Aussie Downtown" (Regional Activity Centre)	"Alphaville" (peri-urban community)	"Utopia" (master planned community)	SEQ ("Lilliput") region (rapidly growing coastal metropolitan region)
	Program 2.10 Redundancy and back-up for essential services and buildings: High priority buildings and services, (Local Disaster Coordination Centres; hospitals; essential council buildings and evacuation centres; alternative access routes; communication; and supplies of power, fuel and water)are decentralised and/ or equipped with back-up systems.				○		●	●
	Program 2.11 Innovative designs for floods: Innovative engineering and design solutions are employed to minimise vulnerability to flooding in low risk areas.		●	●	●	●	●	●
	Program 2.12 Flood immunity: Flood immunity for essential infrastructure and buildings is achieved through water sensitive movement and detention infrastructure that minimises alterations to natural flow regimes, including floodplain connectivity.			○	○	●		●
	Program 2.13 Mapping of flood vulnerable areas: A program is created to map and catalogue developed building sites that are flooded three or more times over a 10 year-period.			●	●	●	●	●
	Program 2.14 Land use conversion: Scenarios for land use conversion are defined to accommodate future population growth and incorporate future projected climate change threats over the next 50 to 100 years.			○	○	●	●	●
	Program 2.15 Flood risk minimisation: A flood preparedness and awareness scheme is initiated to minimise both flash flood and riverine flood risks, including climate change projections, in flood prone areas.		●	●	●	●	●	●
	Program 2.16 Bushfire risk minimisation: A bushfire preparedness and awareness scheme is initiated to minimise bushfire risks, including climate change projections, in bushfire prone areas.			●	●	●	●	●
	Program 2.17 Heatwave risk minimisation: A heatwave preparedness and awareness scheme is initiated to minimise heatwave risks, including climate change projections, in heatwave prone areas.	●	●	●	●	●	●	●
	Program 2.18 Urban parks and open spaces: Urban parks and open spaces are protected, enhanced and restored to protect and strengthen community wellbeing under a changing climate.			○	○	●	●	●
Policy 3. SEQ's planning processes must have strong adaptive capacity to improve decision-making to adapt to climate change.	**Program 3.1 Leadership development:** Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.							●*
	Program 3.2 Capacity building: Local governments' capacity must continue to be built through improved knowledge and skills about climate change.							●*
	Program 3.3 Risk communication on climate change: Communication of climate change risks to decision-makers and wider community (flooding, storm surge, heatwave and sea level rise) must be improved.							●*
	Program 3.4 Risk allocation mechanisms: Climate change risks must be incorporated into decision-making processes.							●*
	Program 3.5 Professional and sub-professional education and training: A mandatory training program is created to educate professionals and sub-professionals in relevant fields on the need to incorporate adaptation to climate change and natural hazards as a basis for establishing design criteria for new infrastructure and housing estates.							●*
	Program 3.6 Anticipatory planning response: The vulnerability of existing settlements in SEQ to climate change-exacerbated hazards, including natural hazards must be reduced through pro-active action.	●	●	●	●	●	●	●
Coastal Management Sector								
Policy 1. Sandy shorelines	**Program 1.1 Beach nourishment in a changing climate:** Instigate a program to defend the current position of the shoreline through erosion control involving a combination of beach	●	●	●	●			●

Policies[11]	Programs[12]	Coastal / Inland: "*Sandy Shores*" (beachfront high rise holiday destination)	"*Blue Waters*" (canal estate)	"*Greenhaven*" (middle suburb)	"*Aussie Downtown*" (Regional Activity Centre)	"*Alphaville*" (peri-urban community)	"*Utopia*" (master planned community)	SEQ ("*Lilliput*") region (rapidly growing coastal metropolitan region)
must be prepared for future coastal erosion events associated with climate variability and change	nourishment, dune restoration and (re)construction, and hard coastal defences							
	Program 1.2 Innovative erosion control approaches: Identify and assess innovative approaches to address coastal erosion, including hard structures, beach drainage and emerging technologies	●	●	●	●			●
	Program 1.3 Dunes restoration in a changing climate: Identify, restore and maintain coastal dune systems threatened by the impact of sea level rise and extreme erosion	●						●
Policy 2. Coastal settlements defended from storm tides risk	**Program 2.1 Storm tides defence system:** Protect vulnerable coastal communities threatened by current and future storm tide events by combining hard and soft defence options to minimize the risk of inundation	●	●	●	●			●
Policy 3. Coastal settlements retreat from vulnerable shores when defence is not feasible - natural function of restored	**Program 3.1 Retreat from high coastal hazard areas:** Develop innovative methods to retreat from areas at risk, including voluntary and compulsory mechanisms such as land swap, land purchase and resumption, land surrender, rolling easements and coastal setbacks to retreat from areas at risk from erosion and storm tides	●	●	●	●			●
	Program 3.2 Restoration of coastal environments: Remove buildings and infrastructure affected by erosion and inundation and those within retreat areas and restore ecosystem functions of beaches, dunes, wetlands and riparian environments	●	●	●	●			●
Policy 4. Coastal settlement in flood prone areas must be designed to accommodate current and future storm tides	**Program 4.1 Space for water:** New space should be identified to allow extreme water levels to be accommodated during storm tides		●	●				●
	Program 4.2 Design standards for buildings and infrastructure: Buildings and infrastructure designs can be improved to accommodate extreme water levels during storm tides. These changes should apply to new and existing buildings and infrastructure	●	●	●	●			●
Policy 5. The Capacity of the community and institutions to face current and future coastal hazards must be improved	**Program 5.1 Community capacity and engagement programs:** Create capacity and engagement programs for coastal rehabilitation and restoration including programs for dunes and wetlands restoration	●	●					●
	Program 5.2 Enhanced coastal education Programs: Integrate climate adaptation into existing school education programs (primary and secondary levels)							●*
	Program 5.3 Enhanced institutional capacities to manage coastal hazards: Build capacity of council officers and other relevant organization to manage coastal hazard areas in a changing climate							●*
Physical Infrastructure Sector (related to local government)								
Policy 1. Asset management of road surface infrastructure improved in order to provide protection against climatic changes, natural hazards and extreme weather events.	**Program 1.1 Road Design:** PI should be enforced through use of alternative construction, material and design.	●	●	●	●	●	●	●
	Program 1.2 Operation of Roads: Advanced operational techniques for maintenance and rehabilitation should be employed.	●	●	●	●	●	●	●
	Program 1.3 Finance for Roads: Cost estimation of climate change impact should be included in asset valuation and depreciation.							●*
Policy 2. Management, design and construction of stormwater systems enhanced to increase resilience to changing climate, natural hazards and extreme	**Program 2.1 Stormwater Systems Design:** PI should be enforced through use of alternative construction, material and design.	●	●	●	●	●	●	●
	Program 2.2 Operation of Stormwater Systems: Advanced operational techniques for maintenance and rehabilitation should be employed.	●	●	●	●	●	●	●

Policies[11]	Programs[12]	Coastal / Inland: "*Sandy Shores*" (beachfront high rise holiday destination)	"*Blue Waters*" (canal estate)	"*Greenhaven*" (middle suburb)	"*Aussie Downtown*" (Regional Activity Centre)	"*Alphaville*" (peri-urban community)	"*Utopia*" (master planned community)	SEQ ("*Lilliput*") region (rapidly growing coastal metropolitan region)
weather events.	**Program 2.3 Finance for Stormwater Systems:** Cost estimation of climate change impact should be included in asset valuation and depreciation.							●*
Policy 3. Adaptive capacity of critical infrastructure strengthened to deal with the unpredictability of climate change impacts	**Program 3.1 Education**: Capacity should be built/improved through knowledge sharing, enhanced understanding and awareness about climate change.							●*
	Program 3.2 Implementation: Current policies and regulations should be redesigned and/or modified to ensure the successful implementation of adaptation actions to improve adaptive capacity of asset management of critical infrastructure.							●
	Program 3.3 Management: A dynamic anticipatory management approach should be employed to learn from others experience, respond to feedbacks, attain innovations and take pro-active action.							●
Emergency Management Sector								
Policy 1. State and local governments integrate long term post-disaster recovery considerations into pre-disaster planning processes.	**Program 1.1 Long term post-disaster recovery plan:** State and Local governments develop a long term post-disaster recovery plan. This plan should identify policies, operational strategies, and roles and responsibilities for implementation that will guide decisions that affect long-term recovery and redevelopment of a community after a disaster.							●*
	Program 1.2 Post-disaster recovery in pre-disaster plans: Long term post-disaster recovery considerations are integrated into pre-disaster plans of government agencies leading recovery processes.							●*
	Program 1.3 Community engagement: Communities are engaged in the development of the long-term post-disaster recovery plans.	●	●	●	●	●	●	●
Policy 2. A series of programs to integrate emergency management and urban planning and management processes to more effectively reduce vulnerability of communities to climate change.	**Program 2.1 Emergency management integrated into land use planning and development:** Emergency management considerations are integrated into urban planning decisions related to land use planning and development.							●
	Program 2.2 Emergency management integrated into state planning policies: The integration of emergency management into state planning policies is improved.							●
	Program 2.3 Strategic relocation and upgrade of essential emergency services: Emergency services and facilities are strategically relocated into low risk areas and upgraded to appropriate building standards to projected risks to ensure these services and facilities can continue to operate during emergencies (include threats to infrastructure).	●	●	●	●	●		●
	Program 2.4 Capacity building and training program: A capacity building and training program on emergency management, climate change and urban and regional planning is developed and implemented.							●*
Policy 3. A series of programs will be introduced to improve the levels preparedness of communities to climate change and new climatic risks.	**Program 3.1 Preparedness of vulnerable communities:** The preparedness of vulnerable communities to current and future climatic risks is improved.	●	●	●	●	●	●	●
	Program 3.2 Preparedness of private and community sectors: The preparedness of private and community sectors to climate change and new climatic risks is improved.	●	●	●	●	●	●	●
	Program 3.3 Real estate sector and hazard awareness: The real estate sector is engaged to improve hazard awareness amongst property owners.	●	●	●	●	●	●	●*
	Program 3.4 Community education and awareness raising campaigns for vulnerable groups: Community education and awareness raising initiatives targeted at vulnerable groups, (new residents and seasonal visitors), are implemented - focused on natural hazard preparedness, response and recovery, and potential climate change implications for the area.	●	●	●	●	●	●	●

Policies[11]	Programs[12]	Coastal / Inland: **"Sandy Shores"** (beachfront high rise holiday destination)	**"Blue Waters"** (canal estate)	**"Greenhaven"** (middle suburb)	**"Aussie Downtown"** (Regional Activity Centre)	**"Alphaville"** (peri-urban community)	**"Utopia"** (master planned community)	**SEQ** (*"Lilliput"*) **region** (rapidly growing coastal metropolitan region)
	Program 3.5 Bushfire Community Training Package: Continue to implement Queensland's Bushfire Community Training Package.			●	●	●	●	●
Policy 4. An integrated group of programs to support and enhance the emergency management capacity and capability of local governments in light of the changing risk profile due to climate change.	**Program 4.1 Redundancy and back up for essential emergency management services and facilities:** High priority emergency management services and facilities, such as Local Disaster Coordination Centres, evacuation centres, hospitals and alternative access routes are decentralised and/or equipped with back-up systems.				●		●	●
	Program 4.2 Local government emergency management capacity: The emergency management capacity of local governments is improved.							●*
	Program 4.3 Communication between local councils: Improved and increased communication between emergency management personnel across local councils is facilitated.							●
	Program 4.4 Support our Heroes: Continue to implement Queensland's Support our Heroes Program to strengthen the response capacity of SES and Rural Fire Service.							●*
Policy 5. Stronger regional collaboration - buddy system	**Program 5.1 Mutually supportive councils:** Councils establish and maintain agreements with each other to provide assistance if required during an emergency event.							●
Policy 6. Support to communities in disaster response and recovery for greater resilience.	**Program 6.1 Community training programs:** Community training programs in response and recovery are developed for community groups.	●	●	●	●	●	●	●
	Program 6.2 Community Leadership: Community leadership during and after disasters is supported to promote improved disaster response and recovery.	●	●	●	●	●	●	●
Human Health Sector								
Policy 1. Responses to human health impacts enhanced through strengthened and expanded health initiatives and emergency preparedness	**Program 1.1 Service Continuity in Disaster:** Emergency Preparedness and Continuity Management assists health facilities to cope with changing risk profiles as a result of climate change							●
	Program 1.2 Heat wave management: Heat wave management and response is improved to minimise health risks during hot weather events	●	●	●	●	●	●	●
	Program 1.3 Psychosocial Support: Mental health and psychosocial support is enhanced through working with vulnerable communities	●	●	●	●	●	●	●
Policy 2. Health risk minimisation and capacity building for communities, private sector and government departments should be assisted through a range of initiatives and programs	**Program 2.1 Community capacity-building:** Capacity to adapt to health impacts is enhanced through identifying and supporting social networks	●	●	●	●	●	●	●
	Program 2.2 Community risk awareness: Health risk management is facilitated through communication and community awareness initiatives.	●	●	●	●	●	●	●
	Program 2.3 Supporting Volunteers: volunteer retention and volunteer capacity to respond to health impacts and risks associated with climate change is improved through volunteer management and training	●	●	●	●	●	●	●

Policies[11]	Programs[12]	Coastal / Inland: *"Sandy Shores"* (beachfront high rise holiday destination)	*"Blue Waters"* (canal estate)	*"Greenhaven"* (middle suburb)	*"Aussie Downtown"* (Regional Activity Centre)	*"Alphaville"* (peri-urban community)	*"Utopia"* (master planned community)	**SEQ** (*"Lilliput"*) **region** (rapidly growing coastal metropolitan region)
	Program 2.4 Improved availability of information: Improved availability of information for health authorities, professionals, private sector and other decision makers assists their capacity to adapt to climate change-related health hazards.							●*
	Program 2.5 Leadership development through collaboration: Leadership must be developed by encouraging strong partnerships across government, business and the community in order to improve communication of climate change risks to decision-makers and wider community.							●*
Policy 3. Integration of health initiatives with policies and plans in other sectors to enhance climate adaptation efforts for human health	**Program 3.1 Integration with Emergency Management:** More integrated actions with Emergency Management assists the delivery of health services for frontline emergency health personnel and vulnerable groups that are susceptible to climate change health impacts	●	●	●	●	●	●	●
	Program 3.2 Integration with Urban Planning and Management: Integration of human health into urban planning and management increases resilience and reduces susceptibility to adverse health impacts of climate change	●	●	●	●	●	●	●
	Program 3.3 Integration with Physical Infrastructure: The vulnerability of communities and health services to climate change is minimised by integrating human health considerations in the planning and management of physical infrastructure.	●	●	●	●	●	●	●
Policy 4. Surveillance & Monitoring strengthened to have timely responses to future climate impacts	**Program 4.1 Improved understanding:** Research, surveillance and monitoring leads to improved understanding of relationships between population health and climate change and capacity to respond to future health risks							●*
	Program 4.2 Risk management and population health: Surveillance and monitoring allows for continuous improvement in risk management at a population health level							●*

KEY

● Program relevant

○ Duel Programs (Inland & Coastal) relevant

* Generic program (context wider than SEQ)

Statutory planning

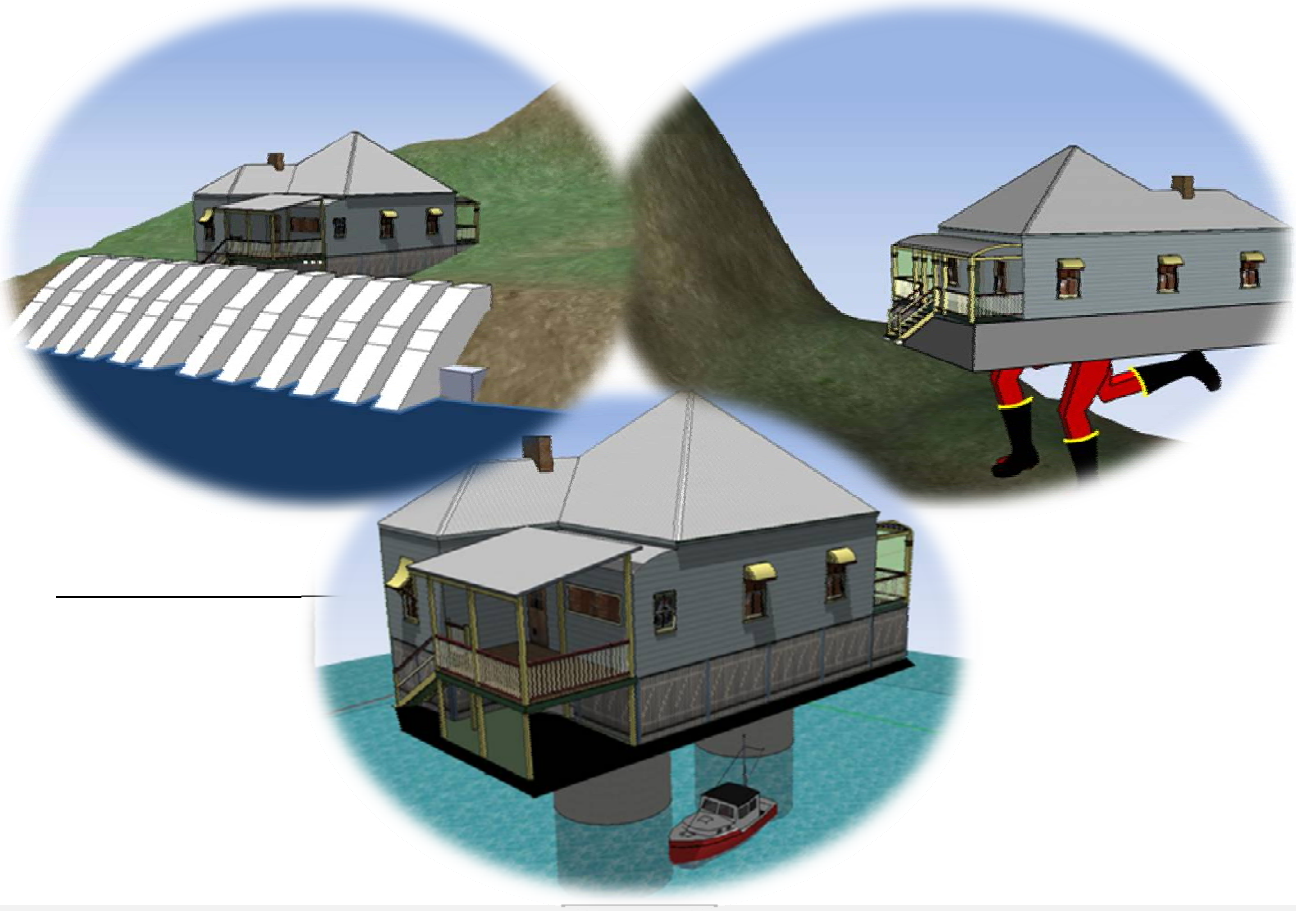
Non-statutory planning

Non-statutory and/or statutory planning

Table F2: Relevance of Sectoral Programs to Adaptation Themes

Adaptation Theme / HS Sector	Preparing the Community	Support for Vulnerable Communities	Leadership, including Community Leadership	Proactive (Anticipatory) Initiatives	Managing the (Urban) Environment	Technological Development and Innovation	Risk Communication	Training and Education
Urban Planning & Management	• Coastal Erosion Risk Minimisation (1.17) • Coastal Inundation Risk Minimisation (1.18) • Urban Parks and Open Spaces (1.19; 2.18) • Flood Risk Minimisation (2.15) • Bushfire Risk Minimisation (2.16) • Heatwave Risk Minimisation(2.17)	• Community Planning (1.3; 2.3) • Retrofitting of Residential Properties (1.6; 2.6)	• Leadership Development (3.1)	• Strategic Relocation and Upgrade of Essential Emergency and Health Services (1.7; 2.8) • Long-Term (Strategic) Planning (1.14) • Coordinated Response to Sea Level Rise (1.15) • Land Use Conversion (1.16; 2.14) • Anticipatory Planning Response	• Consolidation of Urban Development (1.1; 2.1) • Infrastructure Sites (1.2; 2.2) • Building Code Design Criteria (1.4) • Planned Retreat (1.6; 1.7) • Coastal Defence (1.8) • Redundancy and Back-Up for Essential Services and Buildings (1.10; 2.10) • Protection of Coastal Habitats (1.13) • Building Code Design Criteria for Floods (2.4) • Building Code Design Criteria for Bushfire (2.5) • Mapping of Flood Vulnerable Areas (2.13)	• Innovative Design for Coastal Areas (1.11) • Flood Immunity (1.12; 2.12) • Innovative Designs for Floods (2.11)	• Hazards Full Disclosure Clause (1.9; 2.9) • Risk Communication on Climate Change (3.3) • Risk Allocation Mechanisms (3.4)	• Capacity Building (3.2) • Professional and Sub-Professional Education and Training (3.5)
Coastal Management	• Community capacity and engagement programs (5.1)				• Beach nourishment in a changing climate (1.1) • Dunes restoration in a changing climate (1.3) • Storm tides defence system (2.1) • Retreat from high coastal hazard areas (3.1) • Restoration of coastal environments (3.2) • Space for water (4.1) • Design standards for buildings and infrastructure (4.2)	• Innovative erosion control approaches (1.2)		• Enhanced coastal education Programs (5.2) • Build capacity of institutions to manage coastal hazards (5.3)
Physical Infrastructure				• Management (3.3)	• Operation of Roads (1.2) • Operation of Stormwater Systems (2.2) • Finance for Roads (1.3) • Finance for Stormwater Systems (2.3) • Implementation (3.2)	• Road Design (1.1) • Stormwater Systems Design (2.1)		• Education (3.1)
Emergency Management	• Preparedness of private and community sectors (3.2) • Real estate sector and hazard awareness (3.3) • Bushfire Community Training Package (3.5) • Support our Heroes (4.4)	• Preparedness of vulnerable communities (3.1) • Community education and awareness raising campaigns for vulnerable groups (3.4)	• Community Leadership (6.2)	• Long term post-disaster recovery plan (1.1) • Post-disaster recovery in pre-disaster plans (1.2) • Community engagement (1.3)	• Emergency management integrated into land use planning and development (2.1) • Emergency management integrated into state planning policies (2.2) • Strategic relocation and			• Capacity building and training program (2.4) • Local government emergency management capacity (4.2) • Communication between local councils (4.3) • Assistance between

Adaptation Theme / HS Sector	Preparing the Community	Support for Vulnerable Communities	Leadership, including Community Leadership	Proactive (Anticipatory) Initiatives	Managing the (Urban) Environment	Technological Development and Innovation	Risk Communication	Training and Education
	• Community training programs (6.1)				upgrade of essential emergency services (2.3) • Redundancy and back up for essential emergency management services and facilities (4.1)			councils (5.1)
Human Health	• Community Capacity Building (2.1) • Integration with Emergency Management (3.1)	• Psychosocial Support (1.3)	• Leadership Development through Collaboration (2.5)	• Service Continuity in Disaster (1.1) • Heat wave Management (1.2) • Improved Understanding (4.1)	• Integration with Urban Planning & Management (3.2) • Integration with Physical Infrastructure (3.3)		• Community Risk Awareness (2.2) • Improved Availability of Information (2.4) • Risk Management & Population Health (4.2)	• Supporting Volunteers (2.3)



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