Health impacts of climate change:

Adaptation strategies for Western Australia




Delivering a **Healthy WA**

This document has been produced to provide an understanding of the potential health impacts and associated social implications of climate change that may affect the people of Western Australia in the future. It has been based on the limited knowledge of the climatic changes that may affect Western Australia and provides a starting position for future assessments. The information can contribute towards the development of policies and planning by the Government of Western Australia for community adaptations to climate change.

Acknowledgements

The Department of Health acknowledges the expertise and input of the individuals and sectors committed to addressing the potential impacts to public health and wellbeing from climate change who contributed to the investigations and outcomes presented in this document. These participants are listed in Appendix Three.

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Executive summary

It has been demonstrated that the Earth is warming and climatic parameters are changing. In Western Australia, the south west has been experiencing rainfall reductions for several decades and other areas across the State have experienced droughts and atypical events. It is now generally accepted that Western Australia will experience a climate in the near future that is drier, hotter and has more extreme weather events than it had in the past.

The trends in climatic change will impact human populations through their effects on the physical and biological components of the environment. Global efforts are being made to mitigate climate change and reduce greenhouse gas emissions. However it has been accepted that some change will occur and that individuals and communities will need to adapt to these changed environmental circumstances to avoid adverse consequences. Of significance are the potential health impacts on people in Western Australia. The severity of possible impacts on communities will be dependent on our ability to adapt to situations and environments that may be quite different from those we have now.

The Department of Health and the World Health Organisation Collaborating Centre for Environmental Health Impact Assessment at Curtin University recognised that the Health Impact Assessment process provides an appropriate means by which the potential impacts of climate change in WA can be initially assessed. A Health Impact Assessment of Climate Change Project was undertaken in collaboration with Government and other stakeholders to consider the implications of climate change on the health of the people of Western Australia and to develop a range of adaptive responses to provide Government with the basis for future decision making.

The Project was undertaken in two phases. Phase One was the identification of the potential health impacts that could arise given a particular set of climatic situations in the future, consideration of our current coping capacity and identification of health related vulnerabilities of people, regions, infrastructure and the economy to specific climatic and environmental events. The second phase entailed a risk assessment of the health impacts on communities including specific reference to vulnerability, and the development of adaptations which could be used to mitigate the identified impacts.

It was recognised that the lack of detailed knowledge of future climatic conditions in Western Australia, the future distribution and densities of populations and the development of associated infrastructure did not allow for a comprehensive and quantitative assessment of health impacts. What emerged from this project, however, was a good understanding of current activities, their adequacy with respect to health and a range of adaptations and required supporting research.

The outcomes have been designed to provide a proactive approach to the protection of the health of communities in Western Australia from any adverse environmental impacts associated with climate change. They form the basis for future planning and decision making by Governments and other relevant sectors and adaptive responses that can be taken up by society in Western Australia.

1. Introduction

The evidence is growing that the Earth is warming and that future global climatic and environmental circumstances may be significantly different if appropriate mitigation and abatement programmes are not implemented. Studies have indicated that the rate of warming may not be slowed sufficiently to minimise predicted climatic changes. A consequence of global warming is that changes to physical and biological systems will have impacts on human populations and that people and communities will have to adapt to these potential changes to avoid adverse consequences.

In Western Australia (WA) it is now generally accepted that in the near future, we will experience a climate that is drier and hotter in the south west with more extreme weather events and more variable in the north west. As a result of climate change, we may also have to contend with rises in sea-level. These changes are likely to affect a wide range of environmental, human and built systems that may alter, not only the world in which we are living, but also the way we live.

A crucial aspect of life that may be effected by climate change is the health of the people of Western Australia. The type of potential health impacts that may arise will reflect the unique climatic and socio-economic parameters of WA. The extent to which these potential health impacts are realised will depend on how we respond or adapt to the challenges of climate change.

The recent Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report indicated that while the region of Australia and New Zealand *"has substantial adaptive capacity due to its well-developed economies and scientific and technical capabilities,…there are considerable constraints to implementation [of adaptation measures] and major challenges from changes in extreme events."* This statement reflects the strong economic and scientific base that can provide WA with a range of opportunities to address the potential health impacts of climate change. Equally it sounds a warning that institutional, political and financial constraints may hinder such opportunities. It is clear that we need to overcome these constraints and avoid a future of lost opportunities which may have significant consequences.

While measures to reduce or mitigate climate change are being discussed nationally and internationally it is important that consideration also is given to the strategies which will need to be formulated and implemented to mitigate and adapt to the impact of the predicted changes in the likely event that these changes will occur. It has been predicted that the impacts of climate change on human health and safety could be of major significance; hence the need to consider appropriate mitigation and adaptation strategies.

The Department of Health and the World Health Organisation Collaborating Centre for Environmental Health Impact Assessment at Curtin University recognised that the Health Impact Assessment process provides an appropriate means by which the potential impacts of climate change can be initially assessed. In collaboration with Government and other stakeholders such as industry and service providers (see Appendix three), a Health Impact Assessment of Climate Change Project was undertaken to consider its implications on the health of the people of Western Australia and to develop a range of adaptive responses that could provide Government with the basis for future decision making. This report provides the outcomes of this assessment.

2. The assessment process

Management of climate change generally falls under two major areas: mitigation and adaptation. The long-term importance of mitigation is critical as the degree to which global climatic conditions will change is subject to the mitigation efforts that can be made in the near future to reduce greenhouse gas emissions to the atmosphere. However, even with the most optimistic mitigation scenarios, there are projections for significant changes to climatic conditions, particularly over the next 50 to 100 years. The focus of this project has therefore been investigating methods for adapting to the climate change projected to occur over the next 30 years.

Uncertainty is a part of any planning for the future, perhaps more so with climate change than any other situation in recent history. While there is consensus on the broader potential health impacts of climate change on people, actual health outcomes for specific population groups are still largely unidentified. Regardless of the uncertainty, it is clear that we need to plan to protect our health from risks associated with climate change. This planning must be done in conjunction with all aspects and all levels of society.

Health Impact Assessment (HIA) is a formal process which considers potential health issues during the planning stages of proposal development. HIA aims to identify and examine both the positive and negative health impacts of activities and provide decision makers with information about how the activity may affect the health of people.

The HIA framework follows the format of:

- screening
- scoping
- profiling
- risk assessment
- risk management
- decision making
- evaluation.

Further information about HIA can be obtained from the Department of Health at: www.health.wa.gov.au/envirohealth/home/

It was decided that a process would be developed using the HIA framework that provided for the prediction of potential impacts based on a single possible scenario of future climatic conditions and biophysical changes in WA as shown in the box in Section 3.

The process used in this investigation is expected to form the basis for updates in the development of strategies for the mitigation and adaptation of the health impacts of climate changes in WA as more information becomes available on the predicted changes to climatic parameters.

3. Climate change in Western Australia

A critical element of planning for future health impacts of climate change in WA is climate data specific to WA. Recognition of the need for such data was reflected in the establishment in 1998 of The Indian Ocean Climate Initiative (IOCI), a partnership of the State Government of WA, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Bureau of Meteorology (BoM). IOCI aims to provide information relevant to WA that will support informed decision-making on climate variability and climate change in the state.

Initial investigations by IOCI focused on the South West of WA, a region identified as one of three 'highly vulnerable' regions in Australia by the Australian Greenhouse Office. The next phase of IOCI will focus on other regions, particularly the North West and coastal regions.

The projected changes to climatic circumstances for WA are based on a range of models and scenarios but these have their limitations. The uncertainties of these projections are discussed in reports from the IPCC, CSIRO and IOCI (See Bibliography). However, the identification of potential health impacts to the community from climate change in WA was carried out assuming that early projections have validity and will occur. Comments from IPCC indicate there is a possibility that these projections may be underestimated.

Projections for 2030, in comparison to 1990, were obtained from IPCC, CSIRO and IOCI reports, and are summarised below:

- WA will be generally hotter, particularly in inland regions.
- WA will be dryer, particularly in the South West.
- There will be more frequent, intense droughts, heatwaves and fires.
- There will be more intense storms, floods, rainfall events and tropical cyclones.
- Coastal regions will experience an increase in sea level.

The scenario for WA
• Expected average temperature increases of 0.5^{0}C to 2^{0}C.
• Increases in the number of days over 35^{0}C in: *South West* of +1 to + 20 days (now 27 in Perth). *North West* of +10 to +90 days (now 54 in Broome and 156 in Halls Creek).
• Rainfall changes in: *South-West* of 2 to 20% reduction in annual rainfall with a 17% reduction in winter rain days and catchment runoff decreases of 5 to 40%. *North-West* of annual rainfall decreases of 1.5 to 3.5%.
• Sea-Level increases of 3 to 17 cm by 2030 and 25 to 75 cm by 2100.
• For Extreme Weather Events the following are generally accepted: • heatwaves – more per year • droughts – more frequent and severe • bushfires – increased risk • flooding – increased intensity • storms – increased intensity • tropical cyclones – increased intensity.

4. Health impacts

The World Health Organisation (WHO) definition for environmental health was used in this project to establish the range of health determinants that may be affected by climate change and the factors that require consideration.

> *"Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychological factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations" (WHO, 1993)*

The components of the project (Phase One and Phase Two: see below) address the two parts of this definition respectively. Phase One focused on the identification of the range of factors influencing human health that may be affected either directly or indirectly by climate change. A checklist of these factors was used as a tool to identify potential health impacts of climate change in WA (Appendix one).

Phase Two addressed the second part of this definition, namely the management of those factors identified in Phase One. This management requires mitigation of climate change, predominantly by the reduction of greenhouse gas emissions, and adaptation to the climate changes that will occur. Whilst this project recognises the importance of mitigation its clear focus is on adaptation.

The Western Australian Greenhouse Strategy 2004 states, *"…global climate change is already occurring and is projected to continue for many years, even if greenhouse gas emissions were immediately and significantly reduced."* Adaptation responses must be formulated to cope with the effects of the unavoidable climate change that will be felt, regardless of future reductions in greenhouse gas emissions.

The prediction of future health impacts is a challenge because of the highly complex relationships that exist between humans and their environment. The links between a climate variable and a health impact can be very direct, such as physical injuries suffered during an extreme event or increases in respiratory symptoms during high temperature events. Other links are indirect and complex and require careful consideration of the chain of events that lead from climate variable to health impact.

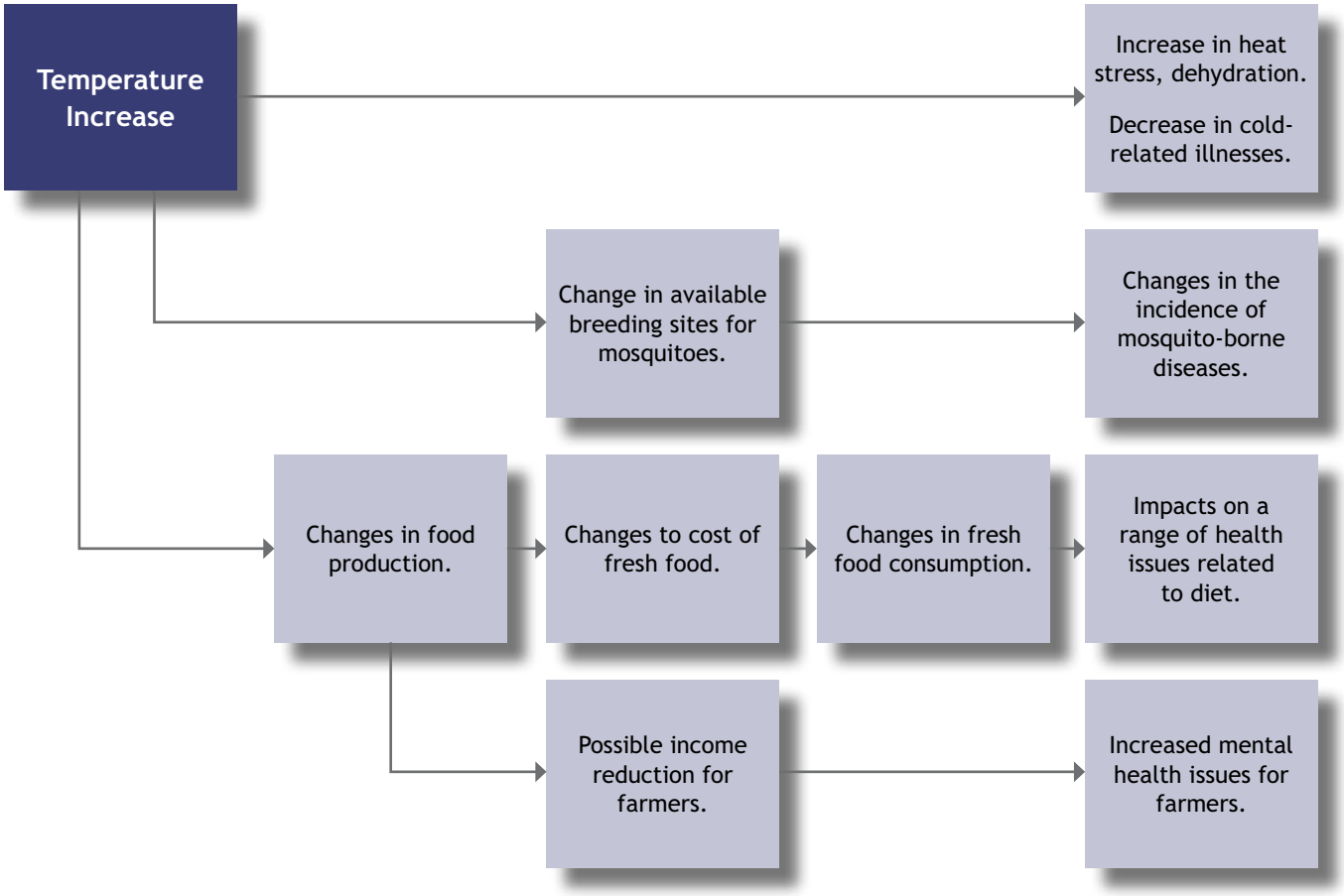
A chain of events or pathways for each potential health impact can be constructed to provide a logical analytical framework to address the:

- Identification of vulnerable groups, regions or sectors.
- Assessment of current coping capacity and the need for adaptation.
- Identification and development of opportunities for adaptation.
- Identification of gaps in current knowledge needed for assessment of coping capacity and/or development of adaptation.
- Identification of the appropriate sectors involved in each link of the pathway.

An example is given in Figure 1 that outlines a number of possible health impact pathways from increases in temperature. These impacts are likely to be both positive and negative. Direct physical impacts of high temperatures, such as heat exhaustion, are likely to increase, whilst direct physical impacts from cold temperatures such as the incidence of influenza may decrease. Impacts on food production and mosquito breeding patterns are highly likely, but the extent and direction of such

impacts is unclear at the moment. Other climatic variables, such as changes in rainfall and extreme weather events, will play a role, as will non-climatic variables such as land cover changes, urbanisation and salinity. In turn, the potential health impacts of these factors will also depend on a wide range of other determinants. Health impact pathways, such as shown in Figure 1, provide a simplified representation of the links between climate, the environment and health to demonstrate the complex relationships that can be used as a starting point for more in-depth analysis.

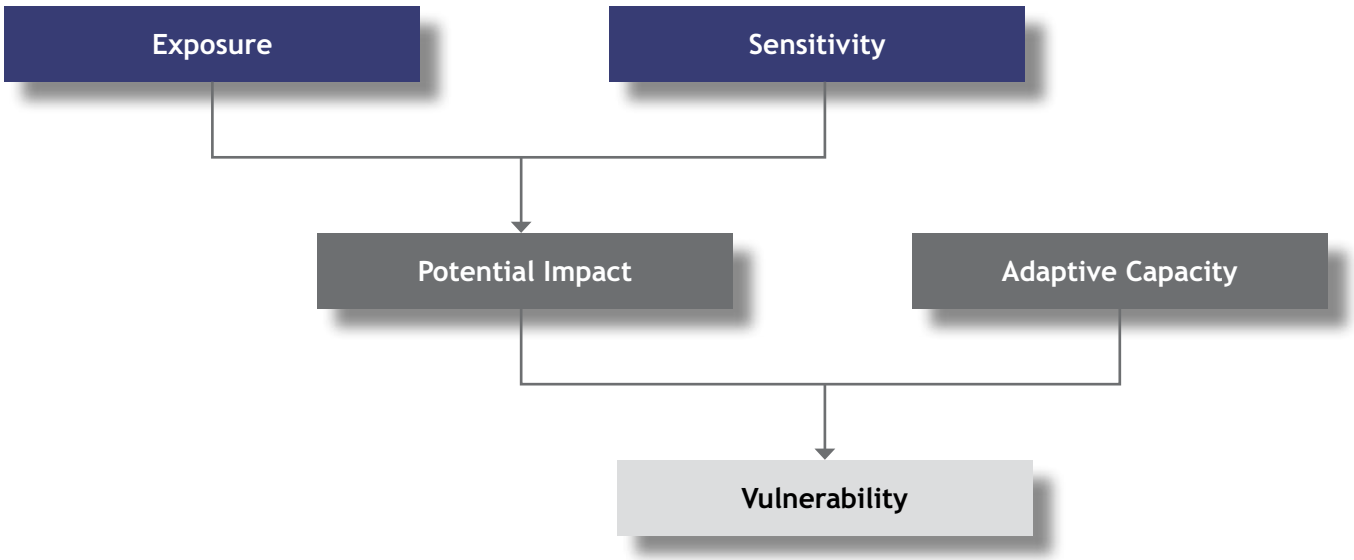
Figure 1: Examples of potential direct and indirect health impacts of temperature increase in 2030.



4.1 Vulnerability

The IPCC defines vulnerability as *"the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change"* (IPCC 2001). Vulnerability is a function of exposure, sensitivity and adaptive capacity (Figure 2). These vulnerabilities can be experienced from a regional or systemic level to community, household and individual levels.

Figure 2: Components of vulnerability



(Australian Greenhouse Office, 2005)

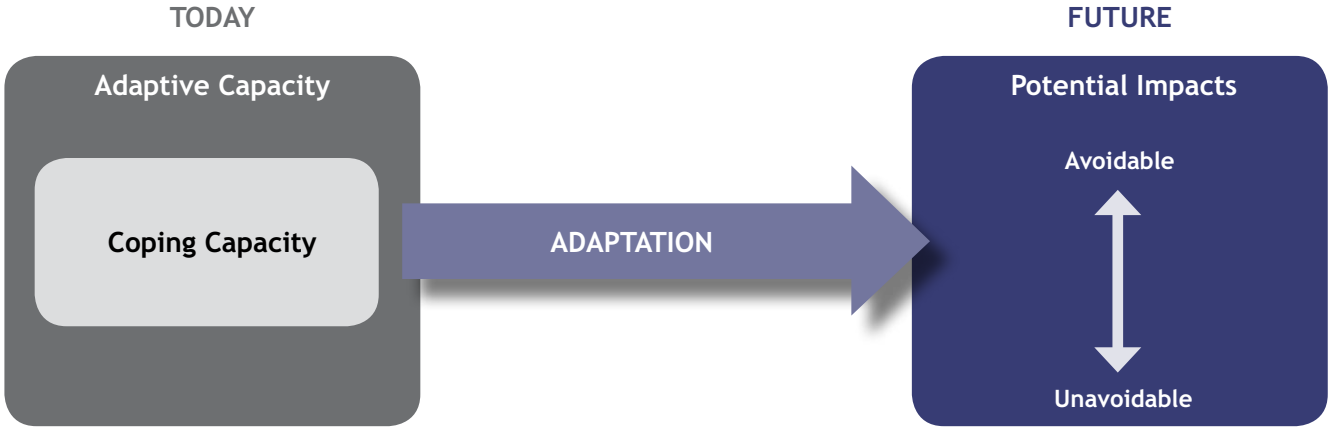
If we return to the concept of a health-impact pathway, it can be noted that each step has a set of unique circumstances that will determine vulnerability. Analysis of each of these steps allows a logical determination of vulnerability and subsequent development of adaptive measures that aim to decrease vulnerability.

4.2 Adaptive capacity

Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with the consequences.

In health terms, coping capacity is a measure of what could be implemented now to minimize the negative health impacts of climate change that may arise in the future and maximize any positives that may occur. An assessment of coping capacity is necessary to determine current vulnerability and to plan appropriate adaptations. Assessment of coping capacity at all levels and for all relevant sectors will provide a thorough understanding of what is needed for management of potential health impacts from climate change.

Figure 3: Adaptive capacity and coping capacity



(Adapted from WHO, 2003)

5. The project

The project was conducted in two phases. **Phase One** focused on the identification of potential health impacts arising from the various types of climatic effects and the possible environmental consequences. The identification of potentially vulnerable groups and regions and an assessment of current coping capacity were included.

Phase Two aimed to assess the potential health impacts associated with the various aspects of climate change and identify possible adaptation strategies that will assist decision makers and others to increase the coping capacity of WA communities.

Professionals from a range of sectors (Appendix three) participated in activities designed to consider, assess and develop adaptation responses to protect the health of people in WA. Whilst a diverse range of participants from health and non-health sectors took part in the project, it is acknowledged that adequate representation from some relevant sectors may not have occurred.

From a health perspective, this project is seen as the first step in a process that will contribute to a cooperative and expressly Western Australian approach to adaptations for climate change. This project aims to not only identify the potential health impacts in WA, but to formulate ways forward that will enable us to start to tackle these issues in practical ways. However, it must be realised that adaptations considered suitable for the level of climate change projected over this time period, may not necessarily be effective for future situations with climate changes of potentially greater magnitude and extent.

5.1 Phase one: Identification of health impacts

A series of health impact pathways was constructed at the Phase One workshop. Attendees at the workshop were assigned based on their areas of expertise, to one of four major areas namely, the physical environment, the built environment, the social environment or environmental diseases and food. This process used expert opinion to identify the potential health impacts that could arise in these sectors.

The potential health impacts and their pathways are included in full in Tables 1 and 2.

Potential health impacts were considered for:

- Increases in extreme events.
- Increases in temperature.
- Decreases in rainfall.
- Increases in sea-level.

The workshop results indicated that the nature of health impacts was significantly different for extreme events and gradual changes.

Table 1: Potential health impacts of extreme events

Impact type	Health impact	Potential impact pathway
Direct Impacts to Humans	Fatalities, injuries Heat stress	• Direct physical injuries from extreme events. • Direct temperature related effects from heatwaves.
Natural Environment		
Water borne	Gastro-intestinal diseases Diarrhoea, vomiting	• Run-off events from heavy rainfall – risk of contamination by disease pathogens such as Cryptosporidium spp. • Contamination from wildlife and stock deaths in drought, bushfires.
Water supply	Water stress	• Effect on quantity and quality of water to reservoirs - increase sediment, nutrient and debris flow. • Changes to land cover – change in runoff patterns.
Vector borne	Ross River Virus disease (RRv) Barmah Forest Virus disease (BFv) Dengue Murray Valley Encephalitis (MVE) Other exotic diseases	• Extreme events will impact on the complex ecological cycles of the diseases, as well as our ability to respond. Direction of impacts likely to be positive and negative. • Changes to climate may allow exotic diseases and vectors to establish.
Food borne	Food poisoning	• High temperatures may increase proliferation of bacterial pathogens including Salmonella, Campylobacter and Listeria spp. • Heavy rainfall events – increased risk of Cryptosporidiosis. • Temperature increase may cause increase in mycotoxins and aflatoxins.
Food production	Changes to diet	• All extreme events particularly in relation to reduced water from rainfall, destroy or damage a wide range of crops and livestock – changes in cost and availability of food.
Air quality	Respiratory effects Asthma Allergic reactions	• Bushfires – increase air pollutants. • Droughts/wind – increase dust. • Heat events – increase smog. • Links between high temperature and ground ozone levels.
Biodiversity	Very difficult to determine. Likely impacts on ecological goods and services	• Wide range of potential impacts on biodiversity, particularly drought and bushfires.
Other	Chemical exposure	• Damage to chemical pipelines, storage. • Drought increases concentration of soil and water contaminants.

Impact type	Health impact	Potential impact pathway
Built environment		
Infrastructure and essential services	Physical injuries Reduced access to health care, food, water Exposure to chemicals, fires, explosions, micro-organisms and other forms of environmental contamination	• Damaged infrastructure/buildings. • Damaged transport systems, energy, water, wastewater, communication. • Off-shore petroleum platforms, pipelines (chemical, gas, water), storage facilities. • Inability to meet increased demand for energy, water, health services. • Breakdown of equipment/computers/ machinery - impact on all services.
Social environment		
Dislocation	Psychological stress of loss of home, community	• Damage to property, homes. • Repeated events - permanent dislocation is possible.
Mental health	Traumatic stress conditions	• Experience of extreme event.
Community	Reduction in sense of community Loss of goods and services Dwindling population	• Negative impacts particularly from repeated extreme events and gradual nature of drought.
Lifestyle/behavioural	Increase in crime, particularly involving aggression Increase in accidents - workplace and traffic Decline in physical health	• Heat waves - hot nights - sleep deprivation. • Times of crisis such as drought and floods - physical health often neglected.
Economic	Stress from loss of income and loss of assets. Reduction of goods and services Inability to insure assets	• Wide range of economic pathways. Loss of income from damage to crops, property, infrastructure such as transport. • Increased cost of insurance, food. • Cost of rebuilding. • Higher maintenance and construction costs with more extreme weather.

Table 2: Potential health impacts of gradual climatic changes

Impact type	Health impact	Potential impact pathway
Direct impacts to humans	Heat stress Temperature related illnesses Cold-related illnesses	• Increase in summer temperature - increase in heat related stress. • Increase in winter temperature - reduction in cold-related illnesses.
Natural environment		
Water borne	Gastro-intestinal diseases Diarrhoea, vomiting Amoebic meningitis	• Temperature increase in recreational waters • Change in incidence of water-borne pathogens such as cryptosporidium, campylobacter, amoeba. • Increase in toxic algal blooms. • Increased use of grey-water - increase contact with pathogenic organisms.

Impact type	Health impact	Potential impact pathway
Water supply	Water stress Water quality Higher cost of treatment	• Reduction in flows to reservoirs, groundwater. • Sea-level rise—salt water intrusion into coastal aquifers, estuaries, wetlands. • Warmer temperature—reduced dissolved oxygen—reduced water quality. • Reduced dam volumes - increases nutrients and contaminant concentration. • Thermal stratification-microbiological inactivation.
Vector borne	Ross River virus disease Barmah Forrest virus disease Dengue Murray Valley Encephalitis Other exotic diseases	• Increase in temperature, rainfall changes and sea-level increases will impact on the complex ecological cycles of the diseases, as well as our ability to respond. Direction of impacts likely to be positive and negative. • Changes to climate may allow exotic diseases and vectors to establish.
Food borne	Food poisoning Seafood poisoning	• High temperatures may increase proliferation of bacterial pathogens including Salmonella, Campylobacter and Listeria spp. • Temperature increase may cause increase in mycotoxins and aflatoxins. • Ocean temperature increase - increase in marine algal blooms -increase Ciguatoxin, southward movement of Vibrio spp.
Food production	Changes to diet Changes to availability of food Changes to nutritional content Changes to pesticide levels	• Climate changes especially in relation to reduced rainfall and available water - change in ability to grow certain foods in certain areas (+/-). • Temperature and CO2 increase - changes in crop yields and protein levels (+/-). • Temperature increase - affect feed intakes and animal reproduction. • Changes to pests, weeds and diseases—changes to use of agrochemicals.
Air quality	Respiratory effects Asthma Allergic reactions VOC gealth impacts Legionnaire's disease	• Increase winter temperature-decrease use wood-burning - improve winter air quality and decrease incidence cold-related illness. • Increase in CO2 levels and dry, hot conditions - increased production pollen, aeroallergens, dust, increased off-gassing of VOCs. • Increased use of evaporative air conditioners and water conserving products (mulch).
UV exposure	Skin cancer, melanoma, Eye disease	• Increased temperature - increase time spent outdoors—increase UV exposure.
Biodiversity	Very difficult to determine. Likely impacts on ecological goods and services Exposure to new diseases Changes to availability of traditional foods	• Wide range of potential impacts on biodiversity - distribution of bacteria, insects, plants and animals.

Impact type	Health impact	Potential impact pathway
Other	Chemical exposure Bites and stings Physical injuries	• Temperature increase—higher use pools and exposure to pool chemicals. • Higher evaporation rates in soils - increase concentration of contaminants. • Increase ocean temperature -southward movement marine tropical pests. • Coastal erosion.
Built environment		
Infrastructure and essential services	Physical injuries Reduced access to health care, food, water Exposure to chemicals, fires, explosions	• Sea-level increase - damage to wide range of coastal infrastructure - buildings, chemical storage, water treatment plants etc. • Drier soils - structural damage to buildings. • Inability to meet increased demand for energy and water.
Social environment		
Dislocation	Psychological stress of loss of home, community	• Sea-level rise and changes in agricultural productivity - forced dislocation for physical or economic reasons.
Mental health	Wide range mental health issues - stress, anxiety, depression	• Loss of income for some primary producers, small business, tourism.
Community	Reduction in sense of community Loss of goods and services Loss of amenities	• Cumulative effects of wide range of climate change impacts and others. • Cut in services to vulnerable communities • Water shortages - loss of green spaces, loss of gardens.
Lifestyle/behavioural	Effect on recreational opportunities Increase in alcohol consumption Decrease coping capacity for hot days.	• Increased temperature - changes to exercise patterns, changes to alcohol consumption. • Increased water temperature - lack of cold water - reduced ability to cool down.
Economic	Stress from loss of income and loss of assets. Reduction of goods and services Financial strain for LG's.	• Wide range of economic pathways. Decreased productivity for some primary producers, loss of income. • Sea-level rise - increase insurance costs, fall in property values, high costs to local coastal governments. • Higher costs of insurance, food, water, energy.

5.1.1 Identification of vulnerable groups

An important component of Phase One was the identification of the various aspects of vulnerability: regional, economic, social and infrastructure and services. Analysis of the workshop responses highlighted a number of vulnerabilities common to a wide range of potential health impacts.

Regional vulnerabilities

Regional vulnerabilities can occur in terms of exposure, sensitivity and adaptive capacity. The projections have indicated that changes to climate will not be experienced equally across the state. For example, reductions in rainfall are likely to be greater in the South West than other regions across WA. Coupled with decreases in rainfall that have already occurred since the mid 1970s, the South West is seen as a particularly vulnerable region.

Communities in coastal regions, particularly low-lying areas, were identified as potentially vulnerable to sea-level rise, storms and sea-surges. The North West was identified as particularly vulnerable to increases in the incidence and severity of tropical cyclones.

In terms of sensitivity and adaptive capacity, regions with a high proportion of rural or isolated communities were identified as more vulnerable to a range of potential health impacts of climate change. Reduced access to essential services and a greater reliance on climatic factors for economic prosperity were identified as the potentially major contributors to vulnerability.

Economic vulnerability

Economic vulnerability was a common theme for a wide range of potential health impacts. Areas or communities, where there is a strong link between economic prosperity and climate were considered more sensitive to climate change than others. Primary producers and tourist-based industries were identified as vulnerable, primarily through reduction in or loss of income. Flow-on effects in these communities include reduction of available goods and services, a decrease in community resilience and reductions in population, all contributing to a decline in quality of life and adverse changes to mental and social health.

Economic vulnerability was strongly linked to adaptive capacity. Communities, households or individuals with low socio-economic levels will be less likely to afford adaptive measures and possible price increases in a range of goods and services. Examples include lack of access to adaptive strategies for temperature increases and heatwaves, such as energy efficient housing and air-conditioning. Low-income families will be more vulnerable to price increases in a wide range of goods and services, including fresh food, water, energy and insurance.

Regions with greater exposure to the impacts from climate change may have economic difficulty in adapting to climate change. Some coastal communities may require major infrastructure expenditure to adapt to sea-level rises and storm surges. Financial difficulties are likely for small regional communities faced with such expenditures. Inhabitants of particularly vulnerable regions may suffer financial losses as property devalues. Higher insurance premiums, restricted coverage and withdrawal of insurance may occur in high-risk areas, leading to negative impacts on business, investment and the community.

Social vulnerability

A number of population sub-groups were identified as particularly vulnerable to many of the potential health impacts of climate change. These groups consist of populations whose health status may be at higher risk and include the aged, young, indigenous groups, disabled, homeless and those with compromised health. The extent of vulnerability within these groups will vary widely, dependent on the specific health impact and other factors such as socio-economic, health and mental-health status.

Indigenous populations were considered more vulnerable because of existing health problems and lower standards of living than non-indigenous groups. A lack of basic infrastructure in remote indigenous communities contributes to a poor adaptive capacity and even greater vulnerability. Remote and coastal communities were also seen as regionally vulnerable and more sensitive to changes in coastal ecosystems.

Aged groups were identified as vulnerable to a wide range of potential health impacts. Direct impacts from increases in summer temperatures and frequency of heatwaves were identified as major concerns. Other impacts for which aged groups were considered vulnerable were food and water-borne diseases and respiratory effects of reduced air quality. An ageing population in WA will increase the significance of impacts on this group.

Children may be more sensitive to certain impacts for a range of reasons including higher metabolic and breathing rates than adults and an immature immune system. Pre-existing illnesses or disease and medication can increase vulnerability to a range of potential health impacts.

Infrastructure and services vulnerabilities

Many of our current infrastructures and services have been planned using historical climate data. There is a risk that these may be inadequate for future climatic conditions. Vulnerability may occur from direct physical damage to existing infrastructure or from a combination of diminishing resources and increased demand for essential services. Figures from the insurance industry show that even small increases in the severity of extreme events (< 10%) can cause multiple increases in damages.

The health of our communities is dependent on the provision of reliable infrastructure and services. Changes in capacity to provide clean water, reliable energy, transport, communication, medical and other services will have direct and indirect impacts on health. Health services in regional and remote communities and outer metropolitan regions have been identified as having limited resources. Responses to these vulnerabilities have commenced, particularly in a number of key sectors such as water and the insurance industry. However, formal assessments of current coping capacities appear to be inadequate in a wide range of other sectors.

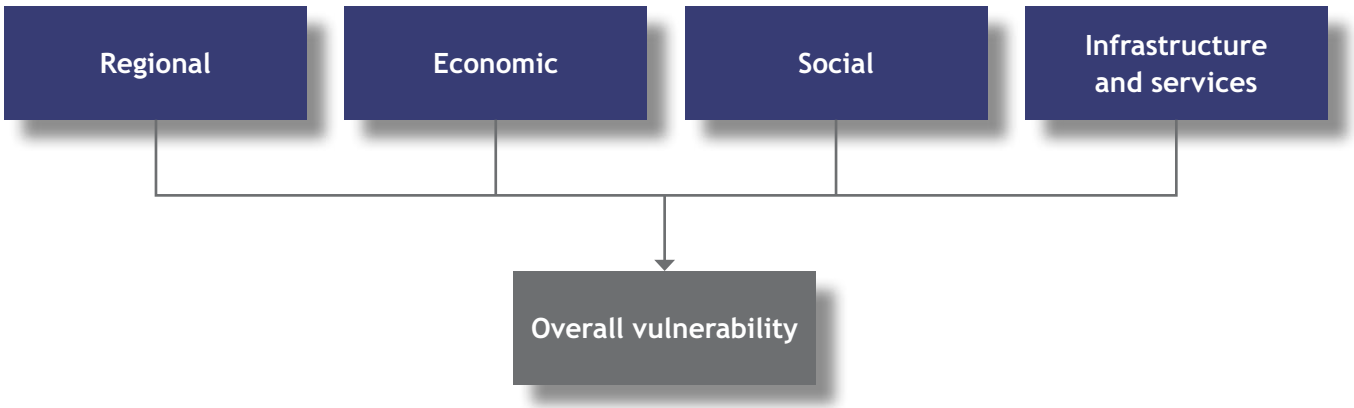
The potential impacts of climate change on coastal development and infrastructure were identified as of major concern, as current planning guidelines in most coastal regions of WA have limited adjustments for projected increases in sea-level.

Specific vulnerabilities

In addition to the vulnerabilities outlined above, some potential health impacts applied to specific vulnerable groups. For example, people who spend large amounts of time outdoors, either through occupational or lifestyle activities were considered vulnerable to vector-borne diseases, UV exposure and heat-related illnesses. Those living in close proximity to mosquito breeding habitats were also more vulnerable to vector-borne diseases.

Figure 4 summarises the major aspects of vulnerability identified at the workshop. Individuals and communities that are vulnerable in more than one of these areas are of particular concern.

Figure 4: Common aspects of vulnerability



5.1.2 Current responses and limitations

The consideration of current coping capacity indicated that in many areas WA is well positioned to respond to events as they occur now. However, a few areas were identified as requiring further capacity building for responses today regardless of constraints that may arise in the future from climate change. It is therefore important that capacity in these sectors is supported and enhanced. Table 3 outlines the identified current coping capacity and associated current and future limitations.

Table 3: Current responses and limitations

Impact type	Current responses	Potential limitations
Direct impacts of extreme events: • Cyclones • Storms • Fires • Heat-waves.	• State Emergency Management Committee. • Disaster Medical Assistance Team. • Cyclone Community Alerts. • All West Australian Reducing Emergencies (AWARE). • State Welfare Emergency Management Support Plan. • Health services/medical treatment. • Adaptation – air-conditioning, energy efficient buildings. • Pensioner subsidies for air-conditioning.	• More extreme events – more demand. • Lack of preparedness/education especially in remote indigenous communities. • Expansion of activities and populations into North-West. • Lack of specific heat-wave response plan • Impacts of energy blackouts on vulnerable groups. • Ageing population – large vulnerable groups.
Natural environment		
Water borne	• Water treatment. • Bacterial and algal bloom monitoring. • Health warnings. • Wide range of regulations and guidelines.	• Need to ensure upgrade of resources, particularly monitoring programs.
Water supply	• State and regional water plans. • Remote Areas Essential Services Program. • Wide range of regulations and guidelines. • De-rating of projected rainfall. • National Water Initiative. • Increased used of grey-water. • Research programs – eg Urban Futures, Rural Futures (CSIRO).	• Possible shortfalls in supply for rural and isolated areas. • Lack of licensing for grey-water use.
Vector borne	• Clinical diagnosis, disease notification, case tracking, mosquito management programs, health warnings, personal protection. • Mosquito and human case surveillance – AQIS, DOH/ UWA surveillance for exotic mosquito incursions.	• Increasing environmental health demands with limited resources. • Increases in household water storage may promote mosquito breeding and hinder management measures.

Impact type	Current responses	Potential limitations
Food borne	• Range of legislation, regulation and monitoring.	• Need for more resources/education. • Emerging and/or unfamiliar pathogens. • Shifting patterns from climate change. • Impacts of changing lifestyles. • Lack of public awareness.
Food production	• Climate Risks and Opportunities Project (CROP). • Research into drought tolerant plants, new cropping practices.	• Restricted access to water. • Limited availability of water. • Greatly reduced rainfall.
Air quality	• Air Quality Management Program. • Medical treatment.	• Lack of resources.
UV exposure	• Education program, awareness	
Biodiversity	• Unknown	• Lack of detailed understanding.
Built environment		
Infrastructure and essential services	• Provision of essential services and infrastructure – wide range government and private providers. • Planning regulations. • Building regulations and codes. • Australian Standards.	• Design/planning based on historical climate data – may be inadequate. • Lack of standardised planning approach to sea-level rise in coastal areas. • Lack of assessment by government sectors and private industry of current coping capacity with respect to climate change. • Lack of assessment of suitability of current building regulations and planning regulations to increase in climate factors such as wind speed.
Social environment There is a general lack of research into social impacts of climate change		
Dislocation	• No current response.	• Lack of research and assessment for viability of vulnerable regions, such as low-lying coastal and drought affected areas. • Research into likely movements of groups – into, out of and within WA.
Mental health	• Range of mental health services across the state, Department of Health, Office of Mental Health, community-based organisations. • Counselling services.	• Already considered under-resourced and inadequate in many areas. • Lack of preventative measures. • Lack of programs to support relocating and retraining of primary producers.
Community	• Wide range of government of community based support. • Child and community health. • Primary Health Care. • Community based programs.	
Lifestyle/behavioural	• Range education programs. • Health Promotion. • Increase in indoor sporting facilities.	• Lack of research into lifestyle impacts of climate change.
Economic	• Financial counselling services. • Exceptional circumstances assistance.	

5.2 Phase two: Risk assessment and management

Phase Two of the project was undertaken in two parts. The first was to carry out a qualitative risk assessment of the identified range of potential health impacts of climate change in WA and the second was to use the outcomes of the risk assessment to identify a range of appropriate risk management or adaptation measures.

5.2.1 Risk assessment

The objective of the risk assessment was to provide a comparison of the relative health risks of the impacts identified in Phase One. It was beyond the scope of the project and in many instances beyond the capacity of available information, to carry out a quantitative assessment of risks.

A group from the participants in the Phase One workshop with expertise in health or risk assessment undertook a qualitative risk assessment in their specific areas of knowledge. A comparative measure of risk is essential for the prioritisation of adaptation measures. The process used was based on that described in AS4360:1999 Risk Management.

Impacts were divided into two broad groups:

1) Impacts with relatively well established relationships between climate and health.
2) Indirect impacts with complex relationships between climate and health.

Impacts were assessed on a qualitative scale that considered the health consequences and the likelihood of the health impact occurring. Categories of risk were low, medium, high and extreme. The levels of uncertainty surrounding consequences and/or likelihood of the potential health impacts were often high, particularly for indirect impacts. In these cases, uncertainties were recognized and a preliminary assessment carried out on the potential impacts. In general a higher level of conservatism was applied for those health impacts with a high degree of uncertainty.

The format for assessing health impacts was adapted from the Australian Greenhouse Office document *"Climate Change Impacts and Risk Management: A Guide for Business and Government"* and standard Health Impact Assessment procedures. A detailed outline of the risk assessment process is included in Appendix one.

The risk assessment process

The objective of the risk assessment process was to ascertain the level and likelihood of risks to public health in WA communities of the identified potential health impacts. These impacts were grouped into key elements based on linked health issues as shown below.

Key Elements
1. Health impacts of extreme events
2. Health impacts of temperature increase and related changes
3. Water-borne disease and water quality
4. Vector-borne diseases
5. Air quality and related health impacts
6. Food-borne diseases
7. Food production
8. Social impact/community lifestyle-dislocation, mental health, and
9. General principles and adaptation measures.

As a qualitative approach was used the risks for each specific health impact were based on the relationship between consequence and likelihood.

Consequence x Likelihood = Risk Priority Level

Two important assumptions were made for this assessment:

1) The year is 2030 and climate change projections have occurred.
2) Only current controls for each health impact are taken into account.

Consequence rating

The consequences of potential health impacts were considered in terms of the magnitude of the impact: judged on the severity of the health impact, the number of people affected, the duration of the impact and the socio-economic implications as shown in Table 4.

Table 4: Consequence ratings

Consequence	Examples
Catastrophic	Large numbers of serious injuries, illnesses or loss of life. Severe and widespread disruption to communities. Long term inability to deliver essential goods and services. Severe long-term reductions in quality of life. Huge economic costs.
Major	Small numbers of serious injuries, illnesses or loss of life. Significant, widespread disruption to communities. Significant decline in delivery of essential goods and services. Significant long-term decline in quality of life.
Moderate	Small number of minor injuries or illnesses. Significant disruption to some communities. Significant decline in delivery of essential goods and services. Significant short-term or minor long-term reduction in quality of life.
Minor	Serious near misses or minor injuries. Isolated short-term disruption to some communities. Isolated but significant reductions in essential goods and services. Minor reductions in quality of life.
Insignificant	Appearance of a threat but no actual harm. Very minor disruption to small section of community. Isolated, minor reduction in delivery of essential goods and services. Insignificant impacts on quality of life.

Likelihood rating

This rating provides an estimate of the likelihood that a risk will occur, given that the proposed climate change scenario comes about (Table 5).

Table 5: Likelihood ratings

Likelihood	Description
Almost certain	Is expected to occur in most circumstances.
Likely	Will probably occur in most circumstances.
Possible	Might occur at some time.
Unlikely	Could occur at some time.
Rare	May occur only in exceptional circumstances.

Risk priority levels

Results from consequence and likelihood assessments were checked against a risk priority matrix (Table 6).

Table 6: Risk priority matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Evaluation

Risk priority levels were compared and evaluated to provide for consistency across priority ratings and adjust for any risks that may have been under or over rated.

5.2.2 Risk assessment results

Using the Consequence Rating, Likelihood Rating tables and the Risk Priority matrix (Tables 4, 5 & 6) each of the components of each Key Elements were considered and assigned a Risk Priority. Table 7 provides the outcomes of this risk assessment process for those impacts with an obvious relationship with climatic event and Table 8 the outcomes where the relationship is more complex. These results have been collated into a Risk Ranking Summary (See Table 17) which has been used to contribute to the determination of Priorities of adaptation responses (Chapter 6).

Table 7: Health impacts with clear climate-health relationships

Impacts	Risk	Rationale
Direct physical impacts of extreme events		
Tropical cyclones	Extreme	• Possible fatalities and injuries. • With current responses it is likely that more intense cyclones will increase the risk of deaths and injuries. • Vulnerable population – mostly in North West region, in particular coastal and remote communities.
Flooding	High	• Possible fatalities and injuries. • Few recorded deaths from flooding, but risk likely to increase due to more extreme rainfall events and sea-level rise. • Vulnerable population – flood zones.
Fires	Extreme-high	• Possible fatalities and injuries. • Frequency and intensity of fires projected to increase therefore with current responses, risk of fatalities and injuries likely to increase. • Vulnerable population – South-West. • Moderate short-term impacts on hospitals.
Heat events	Extreme	• Strong quantitative evidence of increase in mortality in Perth and southwest due to more heat events. • Currently approximately 300 deaths annually, projected to increase to 670 by 2020. • Aging population will increase size of vulnerable group. • Potential for major impacts on the health-care system and community groups during heat events.
Water-borne diseases		
Water-borne diseases from contamination of drinking water in extreme events	High	• Strong evidence linking heavy rainfall events with water contamination, resulting in gastro-intestinal diseases. • More extreme rainfall events likely, risks are likely to increase. • Higher risk in remote Aboriginal communities – estimated 10% increase in diarrhoeal disease in central desert Aboriginal communities by 2050. • Likelihood of outbreaks for general population is lower, but with the potential for major to catastrophic consequences. • Previous incidences of Cryptosporidium spp. have occurred in Perth dams after heavy rainfall events. Current systems may not cope with increased levels of Cryptosporidium spp.
Health impacts from exposure to pathogens in recreational water	High	• Known relationship between temperature, rainfall and levels of pathogens in recreational water. • Incidences requiring public health warnings likely to increase. • Widespread exposure not expected, but increase in incidence of potentially fatal pathogens such as amoeba result in a high-risk rating.

Impacts	Risk	Rationale
Health impacts from exposure to pathogens from grey-water and non-potable water	High/Medium	• Considered almost certain that use of grey-water will increase with climate change. • Large-scale use of grey-water has the potential to expose large numbers of people to pathogens in grey-water that may result in the spread of infectious diseases. • High degree of uncertainty regarding the likelihood and extent of infectious diseases from grey-water. • Increased water scarcity is likely to result in the use of poorer quality sources of water and an increased risk of illness from water borne-pathogens. • Vulnerable populations are those exposed to grey-water or non-potable water such as rural and remote communities.
Vector-borne diseases		
Ross River Virus Barmah Forest Virus Dengue Murray Valley Encephalitis Other – malaria, JE, WNV, Tick-borne, Rodent-borne	High	• Strong evidence linking climate parameters with the incidence of mosquito vectors. • Vectors already present in WA and may spread. • Previously recorded outbreaks of vector-borne diseases in WA associated with weather conditions. • Wide range of possible exposures across the state. • Large degree of uncertainty surrounding the exact impacts of climate change on the incidence of these diseases in WA, but it is likely that impacts will occur. • Need for large numbers of on-going treatment in the case of epidemics is likely to lead to increased strain on the health care system.
Air quality		
Respiratory disease	High/extreme	• Weather conditions can influence formation and transport of harmful air pollutants. • Recent levels of ozone in Perth, in summer, have approached or exceeded accepted standards and evidence is that ozone levels will increase with climate change. • Strong evidence linking levels of ozone and photochemical smog with increased hospitalisation and daily mortality in aged persons. • Large numbers potentially affected in Perth especially in heat events. • There may be some positive health benefits in Perth from reduced particulate matter in winter due to reductions in wood burning, but negative health impacts from increased fires.
Asthma/allergies	High	• Climate change is likely to influence the production of pollen and other allergens associated with asthma and allergies. • Due to the multi-causal nature of these health impacts the relationship with climate change remains uncertain. • Given the links between asthma and pollen production and the high prevalence and health costs of asthma in Australia, the potential risk was considered high.

Impacts	Risk	Rationale
Health impacts from UV exposure	Extreme	• WA has one of the highest rates of skin cancer in the world There is evidence that climate change may slow down the repair of the ozone layer, extending the risk associated with increased UV exposure. • An increase in temperature may increase the 'outdoor' lifestyle, thereby increasing exposure. • Most of the population will therefore continue to be exposed to high levels of UV radiation with catastrophic health consequences.
VOC exposure	Medium	• Evidence that high temperatures increase VOC evaporative emissions from fuel and other sources. • Exposure to VOCs has been linked to a range of sensory, respiratory and carcinogenic health impacts. • Extent of impact on VOC levels and associated health effects is highly uncertain at this stage.
Legionnaires disease	Medium	• Potential for increased exposure through adaptive measures such as increased use of cooling towers and water conserving garden products. • Likelihood of increased incidence of Legionnaire's Disease is unknown, but potential health consequences are major.
Food-borne disease		
Food poisoning	High	• Evidence linking increases in temperature with increased risk of food poisoning. • Australian studies have indicated that with current responses there would be an expected increase in number of food poisoning cases. • Large numbers of people at increased risk. • Higher level of risk is expected in vulnerable groups such as the aged and infants and Aboriginal communities in the North-West.
Mycotoxins	Medium	• Evidence linking cycle of flood/drought with increased levels of mycotoxins in plants. • Current level of mycotoxins in Australian food products is low, so testing is not routine.
Seafood poisoning	Medium	• Ocean temperature increase linked to higher levels of seafood poisoning in some areas of the Pacific. • No specific evidence available for Australia. • Exposure limited to those consuming toxic seafood.
Other		
Bites, stings	Medium	• Irukandji jellyfish moving southward along WA. • Examples of other movements of tropical pests on the east coast. • Potential health impacts are serious, but numbers exposed were considered low.

Table 8: Indirect health impacts with complex climate-health relationships

Impacts	Risk	Rationale
Food production		
Changes to availability/cost of food – reduction in quality of diet	Medium	• Climate change likely to increase the costs of production of food through potential effects of increased extreme events, particularly reduced rainfall and availability of water associated with drought and long periods of drying climatic conditions. • Availability of some foods may decrease. • Ability of lower income groups to absorb these costs may be limited, thereby resulting in a lower nutritional value diet, with less fresh food. • Without additional adaptive measures this may result in a decrease in general health and well-being and increases in diet-related conditions such as diabetes and obesity.
Health impacts from exposure to pesticides	Low	• Considered likely that an increase in pests and weeds will result in an increase in the use of agricultural pesticides. • However if current regulations on pesticide residues in food continue to be met it was considered unlikely that levels of pesticide residues will increase to a level of health concern.
Health impacts from higher levels of imported foods	Medium	• Changes to agricultural practices may result in an increase in the level of imported foods. • Experience with imported foods highlights a concern with food safety in areas of cultivation and food processing. • Assuming only current controls, it is likely that risks of food contamination and associated health impacts will increase. • Although likelihood of health impacts is considered only possible, the consequences could be major.
Infrastructure		
Reduced access to health care, food and water	Extreme	• Increase in the number and severity of extreme events without any further adaptation, will almost certainly result in reduced access to essential goods and services, including medical treatment. • Consequences of reduced access can range from inadequate medical attention to further health impacts from inadequate supply of essential items such as food and water.
Inability to meet demand for energy	Extreme	• Examples of loss in power in Perth as a result of heat events (increased demand) and extreme events, such as fires and cyclones. • Potential reduction of adaptive capacity in relation to heat waves, particularly for vulnerable groups, increasing the risk of heat-related health impacts.
Social Impacts		
Dislocation	High	• Increased risk of temporary dislocation with more extreme weather events. • Increased risk of permanent dislocation due to physical (sea-level rise) and economic (drought) stresses.

Impacts	Risk	Rationale
Mental health impacts	High	• Evidence of links between extreme weather events and mental health impacts. • Level of depression and suicide in rural Australia is high and has been correlated with prolonged drought. With levels of drought projected to increase, risks of associated mental health impacts are likely to increase. • Communities and individuals with strong links between economic prosperity and the climate were considered as particularly vulnerable. • Flow-on mental health impacts from the wide range of potential health impacts of climate change, particularly for vulnerable groups.
Lifestyle/behavioural		
Increase in crime	Medium	• Evidence of links between high temperatures and increased crime, particularly involving aggressive behaviour. • Number of people likely to be impacted considered relatively small with moderate to major consequences.
Increase in accidents	Medium	• Evidence of links between workplace accidents and high temperatures. • Suggestion of similar links with road accidents, but no evidence supplied. • Likely to be limited to heat events and those without adequate adaptive measures.
Sleep deprivation	Medium/Low	• Potential for increased incidence of sleep deprivation during hot nights. • Limited to short periods during heat events and in households with low capacity to cool down.
Health impacts from effects on recreation	Medium	• Likely impacts on recreation patterns, particularly in summer. • This may lead to reductions in healthy exercise patterns and flow-on effects to health.
Health impacts from increased alcohol consumption	Medium	• Potential increases in summer patterns of alcohol consumption, due to temperature increases. • Greater understanding of relationship between climate change and alcohol consumption required.
Neglect of physical health during times of crisis, such as drought	Medium	• Possibility that stresses of extreme weather events, particularly drought, leads to a neglect of physical health. • Given that frequency of drought is likely to increase and considering no further adaptation measures, it is likely that the risk of health impacts from neglect of physical health will increase.
Health impacts from loss of green space and gardens	Medium	• High likelihood of decrease in green space and private gardens as water stress increases. • Flow on effects to quality of life and opportunities for leisure and recreation.

Impacts	Risk	Rationale
Community		
Health impacts from population reduction and loss of goods and services	High	• Reductions in populations seen as likely in vulnerable regions affected by drought and other pressures. • Difficult to identify specific health impacts but will likely include mental health effects, possible reduction in available goods and services, including health care and major reductions in quality of life.
Miscellaneous		
Health impacts resulting from reductions in biodiversity	High	• High degree of uncertainty due to complex relationship between biodiversity and human health. • Changes in distribution of bacteria, insects, plants and animals can have environmental impacts on water, land and air quality that have flow on health effects. • More direct impacts possible in communities with biodiversity related economies. • May include unforseen impacts on biodiversity and flow-on effects to health. • A greater understanding of the links between climate change, biodiversity and health impacts is needed.
Health impacts from increased chemical exposure	Low	• Potential increases in chemical exposure due to higher use of pool chemicals and increased concentration of chemicals in soils and water from higher evaporation. • High degree of uncertainty, with health impacts considered to be relatively minor.

This assessment is considered a 'first-pass' assessment. A greater level of understanding of the potential health risks of climate change will lead to fewer uncertainties and more efficient management options. It is recommended that this is achieved by:

- An on-going reassessment of risk.
- Quantitative risk assessments by relevant sectors where possible.
- More in-depth qualitative assessments by appropriate sectors.

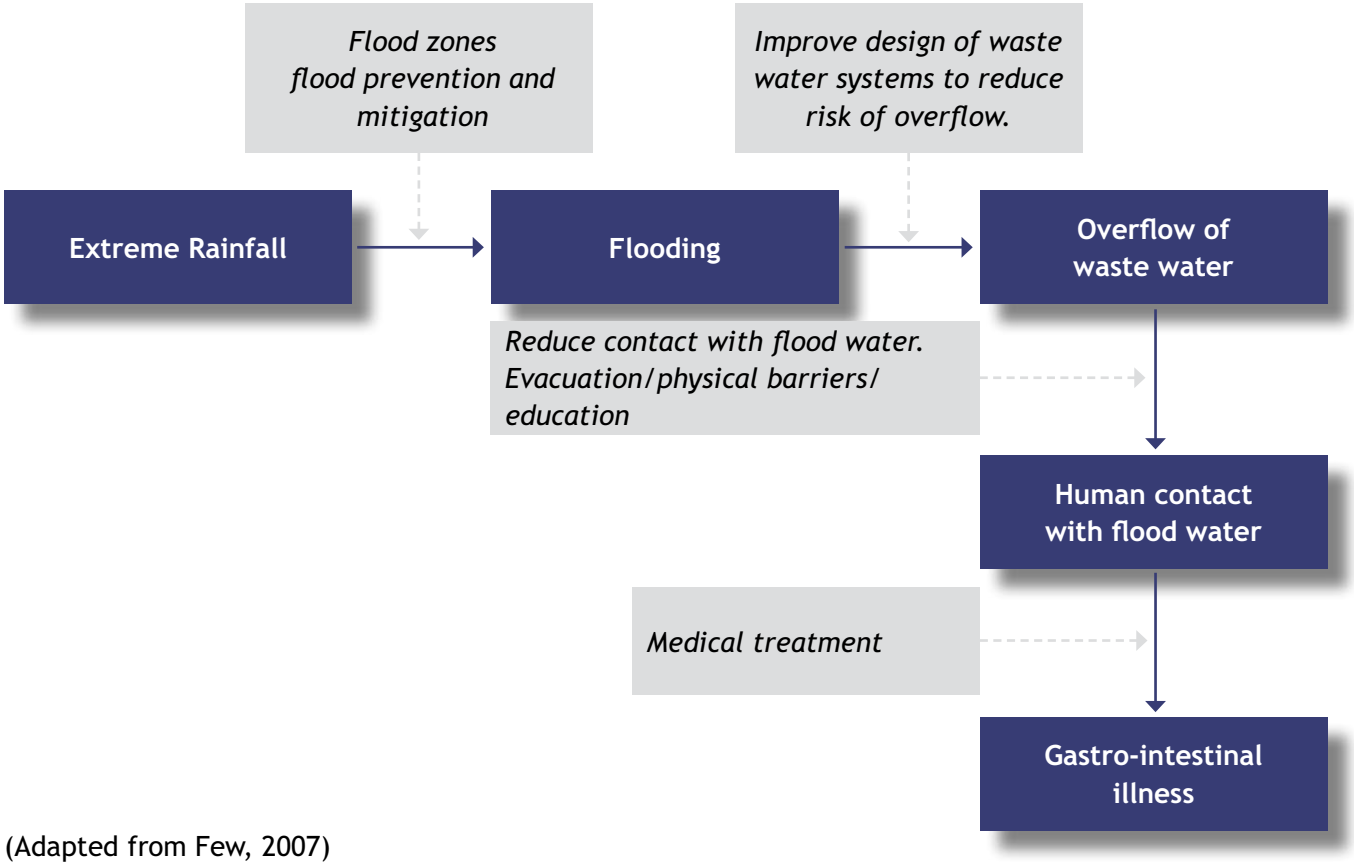
5.2.3 Adaptation measures

Adaptation to climate change in health terms can be broken down into primary, secondary or tertiary measures similar to those used for public health:

- *Primary adaptive measures:* actions taken to prevent the onset of disease arising from environmental disturbances in an otherwise unaffected population.
- *Secondary adaptive measures:* preventive actions taken in response to early evidence of health impacts.
- *Tertiary adaptive measures:* health-care actions taken to lessen the morbidity or mortality caused by the disease" (McMichael and Kovats, cited in WHO, 2000).

Consideration of the chain of events from climate parameter to health impact is a useful method to identify opportunities for adaptation. In general, the earlier in the chain of events that adaptations are applied the better. The example in Figure 5 shows a possible health impact pathway from an extreme rainfall event to a case of gastro-intestinal illness.

Figure 5: Health impact pathway – opportunities for adaptation



(Adapted from Few, 2007)

Each link in the chain of events is at once a potential for vulnerability and an opportunity for adaptation. The primary, anticipatory adaptation measures are the appropriate consideration of flood zones in land-use planning, flood mitigation measures in areas considered at risk and appropriate flood risk waste-water infrastructure. This example serves to demonstrate the importance of non-health sectors in the reduction of potential health impacts of climate change. Similarly, the benefits of these adaptations are not limited to health outcomes. There are obvious economic benefits of minimising physical damage to major infrastructure, property and agriculture.

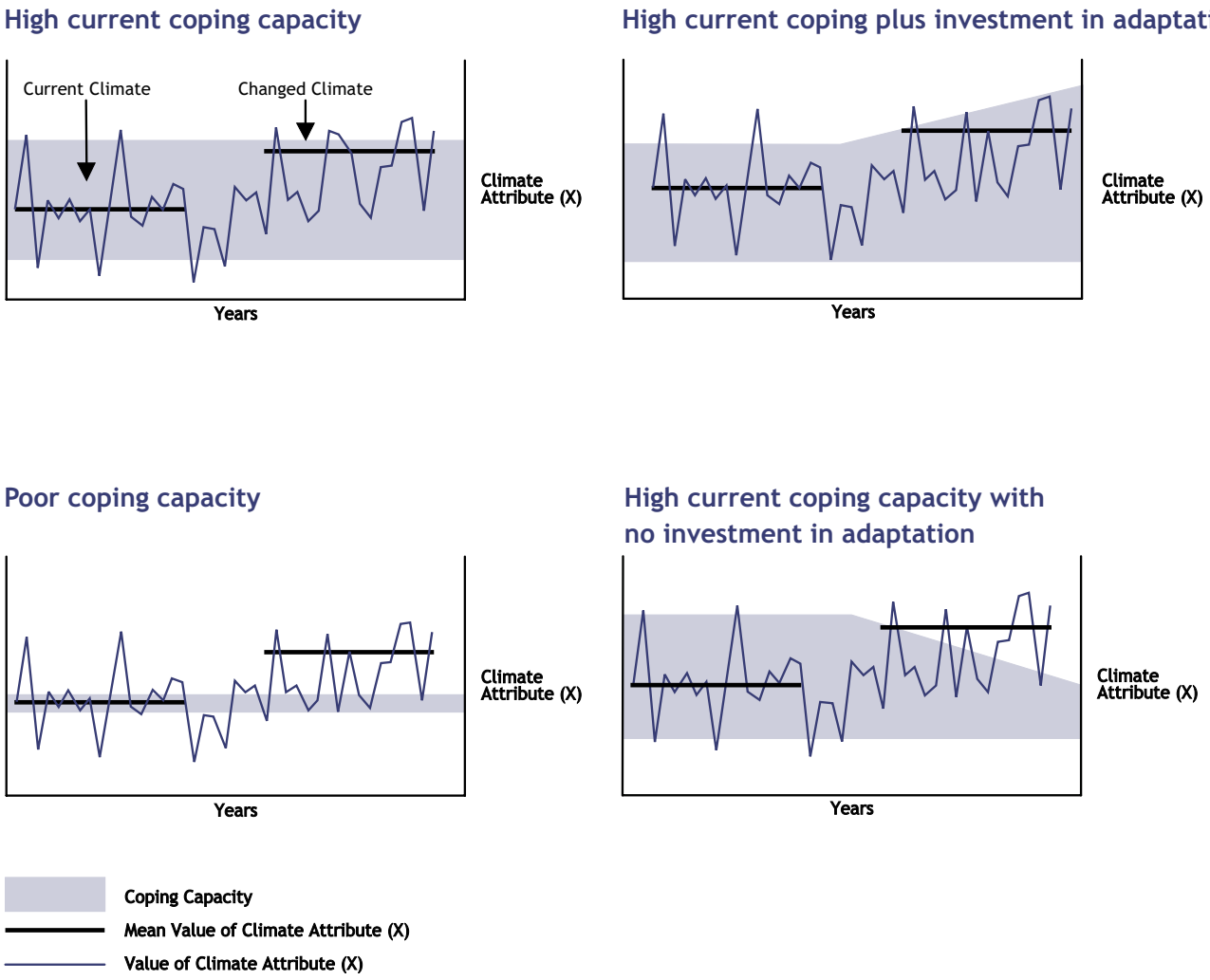
Secondary and tertiary adaptations are implemented in reaction to the contamination of flood waters and are often referred to as reactionary adaptations. Minimising contact with flood waters, through physical separation or improved education, is a secondary adaptation aimed at reducing the extent of the exposure to water-borne pathogens. Medical treatment is a tertiary adaptation taken in response to a health impact that has occurred.

All measures aim to increase adaptive capacity. Adaptive measures may be targeted at the whole population, vulnerable regions or vulnerable subpopulations. Measures focused on vulnerable groups are likely to provide the greatest reductions in risk and therefore the greatest improvements in health outcomes.

The following panels (Figure 6) depict the varying public health coping capacities for current and future climate attributes. WA currently has developed Public Health systems and therefore potentially high coping capacity as demonstrated in the first panel. However, there are parallels with the second panel for Indigenous communities and vulnerable groups within WA. The third panel provides the

circumstances of a state which invests in adaptation responses and enables them to deal with future climate changes, while the final panel reflects the outcomes of little or no investment in adaptation. We need to ensure that with a changing climate our coping capacity can meet the needs of the all groups within the State and thus investment in adaptation is important.

Figure 6: Climate change and coping capacity



(WHO, 2003)

5.2.4 The development of adaptations

A range of possible adaptation measures that could be applied to each of the potential health impacts were identified prior to the second workshop and the following considerations applied:

- Relevance for WA.
- Current capacity in this area, inclusive of vulnerable groups/regions; current coping capacity rated as Not in Place (N), Inadequate (I), Being Developed (D), Adequate (A) or Unknown(?).
- How adaptation could be implemented in WA (adjustment/modification of existing measures or the development of new measures).
- Identification of sectors that would be involved in the development and implementation of this adaptation.
- Other possible adaptation measures, addressing the above issues.

The impact types for consideration were those used previously and identified as Key Components:

- Health impacts of extreme events.
- Health impacts of temperature related events.
- Water-borne diseases.
- Vector-borne diseases.
- Air quality health impacts.
- Food-borne diseases.
- Health impacts from food production.
- Social/community/lifestyle impacts.
- General principles and adaptation measures.

the adaptation measures for each of these topics were categorised as:

- Legislative or regulatory
- Public education or communication
- Surveillance and monitoring
- Ecosystem intervention
- Infrastructure development
- Technological/engineering
- Medical intervention
- Research/further information.

It was noted that there could be health impacts from the implementation of adaptation strategies which would also need consideration. Examples of these are the use of grey water, increased use of imported food, increases in the use of air conditioners and increasing use of rainwater tanks.

5.2.5 Adaptation outcomes

The responses for the specific health impact topics are provided in the following Tables 9 to 16 adapted from Pollution Probe (2002). Part a of each Table indicates those adaptations that can be implemented by decision makers while those for Part b outline the research responses required to support the knowledge base for decision making.

Table 9a: Key component 1 - health impacts of extreme events: tropical cyclones, storms, floods, bushfires

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Cost sharing mechanisms for compensation and adaptation initiatives. • Regulations for minimum building standards to withstand extreme events in vulnerable locations. • Regulations regarding fire management, property management to reduce risk of injuries. • Mid to long-term strategies for land use planning that account for likely impacts.	N A A N	• Only private insurance. • Amend regulations as required. • Amend regulations as required.	• Appropriate upgrades of procedures and assessments as climate change projections and assessment dictate.	• Treasury and all agencies • Insurance • Planning • Housing • Consumer Affairs • Emergency Services • Allied industries
Public education and communication				
• Improvement in communicating risks of extreme events to vulnerable regions and groups tailored to meet their specific requirements. • Education about measures to reduce risk of damage or injuries. • Evaluation of the effectiveness of educational materials.	I/D D I	• Continued Improvement. • Greater investment required. • Coordination with Federal Gov't required.	• Wide community engagement. • Modern communication to be available for all (eg broadband).	• Communication • Health • Local Gov't
Surveillance and monitoring				
• Standardization of information collected after disasters to more accurately measure morbidity and mortality. • Evaluation of responses and health outcomes of extreme events. • Monitoring of hazard mitigation management measures to reduce risk (fire breaks, fuel loads, flood management, trees near power lines etc). • Monitoring the insurance industry for potential changes in insurance coverage for damage claimed resulting from extreme weather events.	I I A A	• Long-term follow up is not adequate. • Hospital morbidity data is OK.	• Need access to General Practitioner data. • Need up to date environmental and population data and forecasts. • Monitoring needs upgrading as required. • Insurance coverage changes will impact on community capability and resilience in dealing with extreme weather events. • Personnel capacity.	• Health • Planning • Environment • Climate • Research • Emergency Services • Insurance industry

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Ecosystem intervention				
• Monitoring the effects of altered land use on vulnerability to extreme weather events.	A		• Upgrade as needed. • Mostly mitigation but needs to address adaptation and prediction.	• Environment • Agriculture • Research • Water • Planning
Infrastructure development				
• Create or enhance emergency management - communication, preparation, training, volunteer recruitment, emergency response coordination, resource allocation. • Mapping of potential risks from extreme events – location of hazardous facilities, vulnerable properties/infrastructure/transport/people. • Land use planning and management to minimize impacts from cyclones, flooding and fire (protective structures, controlled burning). • Restrictive land use zoning for potentially vulnerable regions (sea-level increase, storm surges, cyclones). • Assess ability of current infrastructure/buildings to withstand extreme events. • Make adjustments to infrastructure to ensure the safety of vulnerable groups. • Ensure evacuation is possible via airstrips/roads with adequate infrastructure in place for this in remote areas. • Consider adequacy of current flood plain zones in relation to sea-level rise and coastal erosion. • Development and implementation of sustainable infrastructure. • Ensure adequate telecommunications infrastructure is in place for communications prior to and during events and repairs after events.	I/D I/D I/D I/D I/D I/D I/D I/D I I/D	• North West seen as vulnerable. • All understood to some extent. • Highlight necessity to Treasury to upgrade infrastructure as needed.	• Emergency system needs to expand to cope with more frequent and more severe extreme events.	• Emergency Services • Health • Local Gov't • Planning • Water • Energy • Transport
Technological or engineering				
• Improvement of systems – internet, radio etc to provide early and accessible warning to the populations most likely to be affected. • Modification of building codes for structures in vulnerable areas. • Construction of seawalls – allowing for port access. • Construction of cyclone rated buildings. • Improvements in fire-fighting resources – technology, equipment.	D/A I ? I A	• Systems are in place. • The main issues are access to information and whether people take notice.	• Expand resources as required.	• Climate • Research • Building

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Health intervention				
• Improved training programmes and information on emergency management. • Assessment and implementation of appropriate health professionals and equipment supply management. • Increased level of first-aid training of community members in vulnerable regions. • Increased allocation of appropriate resources and personnel.	A A N I/D	• Enhance responses to rural and regional areas.	• Continue development	• Health

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 9b: Health impacts of extreme events: research/information requirements

Research/Information	Capacity*	Sectors
• Regional assessments of vulnerability to extreme events, especially remote indigenous communities. • Regional identification of vulnerable communities and individuals. • Evaluate effectiveness of early warning systems. • Ensure local emergency management committees function effectively. • Further development of early warning systems – tropical cyclones, fires, droughts. • Ensure State Welfare Emergency Committee has capacity to assist with extreme events. • Modelling of the effect of extreme events in potentially affected regions - transport strategies etc. • Strengthening public health infrastructure in vulnerable communities. • Climate change research. • Capacity of volunteers in extreme events – ageing population, more events. • Communication with remote and mobile populations. • Need to understand specific systems – more research from large regional scale to district and local scale. • Information/research/data needs to be coordinated – data linkages between appropriate sectors, both public and private. • Disaster medicine and emergency management – applied research.	All either I/D	• Whole of Government • Health • Research • Climate • Local Gov't • Indigenous

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 10a: Key component 2 - health impacts of temperature related changes: heat events, increased temperature

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Heat Event Response Plan Extreme Heat Alert. • Regulations for minimum energy efficiencies in homes. • Regulations to introduce limited power use in high demand/emergency periods. • Load shedding - to ensure provision of energy for essential services and communal cooling centres (rec centres, shopping centres). • Legislation to commandeer infrastructure such as cold-storage. • Legislation to protect vulnerable groups - elderly and young.	N D N N N	• State Emergency Plan - no specific heat event plan. • Climate Change Action Plan for new houses. • 5 star codes for new houses.	• Extend State Emergency Plan to include heat events. • Consider energy limits in times of emergency. • Extend to existing homes.	• Health • Emergency • Local Gov't • Planning • Housing • Energy
Public education and communication				
• Declaration of heat emergency and response plan. • Communication plan to aged care facilities, refuges for homeless, day-care centres, schools. • Adequate communication for difficult to reach groups - remote, non-English speaking tourists, mobile population. • Implementation of education campaigns on heat avoidance procedures and management of health impacts. • For inclusion in heat response plan - guidelines for school attendance, sporting events. • Examine previous successful health campaigns aimed at whole of population (eg slip, slop, slap).	N N N N N D	• Capacity is there in general but would need to ensure delivery reaches all groups - tourists, remote areas. • Vulnerable people who are visiting WA especially those who don't speak English. • As above for communication to aged care. • Capacity to deliver through public health campaigns.	• Would be part of a Heat Event Response Plan. • Need to ensure effective communications during power shortages. • Training required for relevant staff and carers of high-risk groups. • Need system to ensure that all agencies dealing with vulnerable groups are well educated in heat avoidance measures.	• Health • Climate • Tourism • Education • Emergency • Local Gov't • Welfare • Recreation • OSH
Surveillance and Monitoring				
• Analysis of daily mortality and morbidity data during heat events.	I?	• Hospitals would need to participate.	• Community services, hospitals would need to collect this information. • Would need to be regulated, backed by legislation. • Tie in with risk prevention. • Link data with response plan.	• Health • Emergency

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard – in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Ecosystem intervention				
• Plant more trees in urban environments. • Introduce green roofs. • Reduce hard surfaces in urban areas. • Increase education of importance of trees in residential areas. • Use of grey-water and recycled water to provide green spaces.	? N I/D ? D	• Need to ensure good planting design – water wise, provision of shade, low maintenance. • Also problems of smaller blocks with no room for trees.	• Increase requirement for green space in developments and urban planning. • Ensure retention of some trees in urban developments.	• Planning • Housing • Local Gov't • Environment
Infrastructure development				
• Improved housing and public buildings (eg, insulation, guidelines). • More effective design for air conditioning units. • Improvement of urban design to reduce urban heat island effect. • Provision of communal cooling areas for vulnerable groups. • Diversify power supplies. • Demand management to reduce peak power use for air conditioning. • Indoor swimming pools. • Need appropriate management to ensure good hygiene. • Consider the costs of vegetation loss in infill development. • Extend current regulations to water efficiency, building materials. • Encourage alternative energy. • Infrastructure needs to be upgraded to deal with water recycling and reuse.	D D I I D D D D I I D I/D	• Risk of diseases increased in swimming pools due to higher temperatures. • Much current housing in remote Indigenous communities is inadequately designed for extreme events.	• Swimming pool water – need designs to include shading. • Remote communities- ensure adequate shading and cooling areas. • Building below ground in North West. • Design infrastructure to cope with climate change (eg pole top fires are a risk). • Need programs to encourage or subsidise alternative energy sources. • Electricity and water infrastructure needs to be 'climate proofed'.	• Planning • Housing

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Technological or engineering				
• Implementation or enhancement of heat event warning systems. • Improved housing and public building design (eg, insulation, guidelines, passive-solar). • Development of preventative measures other than air conditioning. • Pricing of energy and water - incentives for industry to reduce consumption. • Building codes need to be periodically reassessed in light of new climate projections and new advances in building material and technology.	N D D ? D	• Current public warning system - needs industry involvement. • Is regional forecast adequate?. • Premier's Climate Change Action Statement. • Solar passive building design. • Smart-meters.	• Industry could be encouraged by incentives such as Carbon Trading to develop and use relevant technology. • Need heat index mechanism for people vulnerable to heat stress. • Pricing of energy and water. • Need incentives to improve housing and building design especially for remote areas including enforcement. • Improved building regulations and guidelines. • More awareness and installation of smart meters.	• Climate • Health • Housing • Water • Planning • Industry • Resources
Health intervention				
• Better assessment of personal exposures associated with heat-related illness. • Improved training of health professionals and support staff in charge of vulnerable groups - aged cared, hostels, day-care centres, schools. • Planning for hospital and nursing home staffing increases during heat-events. • Adjust work schedules to avoid heat-stress exposure. • Identification of people at risk and register of vulnerable individuals/groups.	I/D N N N N	• All adaptations considered necessary - main issue is one of resources. • Volunteers considered as an option - need to plan for ageing population. • Vulnerable groups well identified and appropriate contingency plans developed.	• Need to educate parents, teachers, carers, worksite management about heat risks. • Need simple remedial measures to prevent heat stress and reduce pressure on the health system. • Need education, public health education. • Work and industry to reschedule work during heat events.	• Health • Education • Industry • Resources • OHS • Research

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 10b: Health impacts of temperature related changes: Research/information requirements

Research/information	Capacity*	Sectors
• Assessment of coping capacity in heat events for health care system and energy sector. • Improvement in the early prediction of heat episodes by determining the key weather parameters associated with poor health outcomes. • Better understanding of physiological and behavioural acclimatization. • Predictive modeling of temperature-mortality relationship in different populations and vulnerable groups (eg. obese, Indigenous communities, children, elderly). • Better understanding of the role of air conditioning in reducing impacts. • Urban design – investigate what level of vegetation is required to reduce heat-island impact Research into the impact of the ageing population on our heat event responses. • Development of strong 'aged' networks. • Aged group is traditionally major part of volunteer base – how will vulnerability of this group affect volunteer capacity?	All either N, I or D	Health Emergency Research Planning

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 11a: Key component 3 - water-borne diseases and water quality: contaminated drinking water from extreme events, exposure to pathogens in recreational water, grey-water and potable water

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Development and enforcement of water quality standards. • Regulation for use of grey-water and grey-water products. • Building/construction standards for facilities that potentially impact on water quality – eg chemical storage, waste-water treatment. • Inclusion of climate change and health considerations in environmental impact assessments. • Water Conservation regulations. • Regulations for retrofitting on all building types.	A/I I/D I/D D/I D/I A/D	• Generally adequate except in small remote communities. • Inadequate for small scale and rural scale. • Being developed but inadequate. • Use of incentives, sprinkler bans.	• Decrease cost of equipment and technology for remote communities and new urban developments. • Increase training for maintenance of systems. • Introduction of 3rd pipe guidelines. • Current incentive based system; possible regulation/ assessment of water resources so water can be allocated. • Draconian or smart regulations?.	• Health • Water • Local Gov't • Planning • Local Gov't • Health • Environment • Health • Water

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Public education and communication				
• Public awareness/hygiene campaigns in vulnerable communities about water-borne diseases after extreme events. • Education on correct use and treatment of grey-water. • Education on correct maintenance of private water storage. • Water conservation incentives for private and community based water conservation programs. • Financial incentives to ensure compliance with new standards and upgrading of existing substandard equipment such as rainwater tanks. • Community engagement to make informed decisions. • Education programmes tailored to appropriately meet the needs of vulnerable groups.	A? I I I D D	• Greater investment needed (Coordination with Federal Gov't). • Public knowledge is limited to what is obtained from Health Dept website, staff and popular media. • Brochures need updating.	• Community engagement as opposed to education. • Improve grey water information and communication. • Regulations for water storage design and maintenance. • Accessible information to community groups. • Using media attention of crisis situations to inform eg Esperance, New Orleans. • More affordable systems. • Partnerships between community, industry, government and target schools for education.	• Health • Local Gov't • Water
Surveillance and monitoring				
• Monitoring and data collection of water quality with reference to climate variables. • Enhanced private water testing. • Improvements in surveillance and prevention of water-borne disease outbreaks. • Monitoring of wastewater re-use. • Water quality monitoring and availability. • Related monitoring of environmental toxins and reduction targets. • Possibility of easy to use water testing kits, eg swimming pool kits.	I I I I I I	• Limited monitoring and compliance assessment capacity within DOH for state-wide and Local Gov't based wastewater reuse schemes.	• Smart sampling system. • Increase sampling facilities. • Increase capacity to test for contaminants and pathogens. • Regular monitoring and auditing of wastewater reuse systems.	• Health • Environment • Local government

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Ecosystem intervention				
• Protection of water catchment areas from contamination - preservation of natural habitat/wetlands, revegetation of river catchments. • Protection of quantity as well as quality - ecosystems do use the water. • Better ecosystems based planning for urban development.	D	• Other water sources - MAR, stormwater, algal blooms, recycled water, groundwater to ecosystems. • Developments on previous catchment areas as catchments become less necessary due to desalination.	• Development of guidelines for disposal to wastewater.	• Environment • Health • Planning
Infrastructure development				
• Emergency management plans for environmental water and water infrastructure. • Assessment of water and waste-water infrastructure with regard to increased risk of extreme precipitation events and droughts. • Use of climate forecasting in water planning. • Improved housing and sanitation practices in vulnerable communities. • Ensure equal access to safe, clean potable water and sanitation. • Development of water quality protection from agricultural, industrial and municipal wastes, power outages and desalination. • Wastewater systems, particularly household systems to have emergency management plans • Climate resilient resources. • Carbon neutral water sources. • Improve water quality in remote areas to meet acceptable standards.	I	• Some are in place. • Need greater investment to raise water quality standards in remote areas. • Wastewater requires power to pump - extreme events reduce energy availability.	• More robust contingency planning. • Protocol for updating emergency plans regularly. • Health assistance for implementation of emergency plans when incidents occur.	• Emergency • Water • Climate • Housing • Environment • Agriculture • Planning
Technological or engineering				
• Redesign of water control structures to handle greater variability of precipitation - storm-water drains, increased absorption capacity of urban landscapes. • Improving reliability of water and waste-water systems in vulnerable communities. • Temporary measures to reduce the pathogen concentration in drinking-water, such as chlorine tablets and boil-water alerts. • Use of smart technology; remote telemetry; innovative technology. • Development of water testing kits much like swimming pool kits. • Increased use of non-potable water sources in homes.	D I ? ? ? D/I		• Part of water reform and irrigation review. • Increase capacity for infrastructure and maintenance in remote areas. • Decrease cost of systems. • How far do we go with purity?	• Water • Local Gov't • Health • Water

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Health intervention				
• Appropriate medical treatments and public health responses in place in response to water-borne infections. • Ensuring access to treatment in remote and vulnerable communities. • Increased training on symptoms and early treatment of water-borne diseases in vulnerable communities.	A A I	• Water-borne disease will increase but will always be small fraction of total demand for medical services.	• Provide training and education to health system and general community (including schools).	• Health

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 11b: Water-borne diseases and water quality: research/information requirements

Research/information	Capacity*	Sectors
• Regional assessments of water-climate health issues and identification of vulnerable communities especially remote Indigenous communities. • Determination of links between land-use and water quality - better assessment of the watershed level of the transport and fate of microbial pollutants associated with rainfall. • Relationship between temperature, extreme rainfall events and incidence of water-borne infections. • Molecular tracing of water-borne pathogens. • Understanding of the links between drinking water, recreational exposure, and water-borne disease monitoring. • Undertake vulnerability studies of existing water supply and sanitation systems. • Development of new systems and education materials that aim to reduce vulnerability in high risk communities. • Research on grey-water use and potential health risks. • Effect of temperature and extreme rainfall on Cryptosporidium spp. in water supplies (including groundwater) and treatment options. • Consideration of the viability of remote communities prior to major investment in infrastructure.	I/D in all	• Health • Climate • Water • Research • Environment

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 12a: Key component 4 - vector-borne diseases:
RRv, BFv, Dengue, MVE, Malaria, rodent-borne, tick-borne and others

Possible adaptation measures	For each potential adaptation measure:		Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?	How can this measure be implemented or upgraded in WA?	
Legislative or regulatory			
• Regulations/guidelines for control of mosquito breeding in domestic container and constructed water body habitat eg rainwater tanks, sewage ponds, lakes. • Regulations/guidelines for food storage to prevent rodent breeding. • Ensuring vector control is considered by all relevant sectors. • Requiring developer responsibility for vector management where development occurs contrary to expert advice. • Provision of officer resources at various government levels to inspect and regulate.	I I I I I	• Inadequate resources for developing regulations, working with stakeholders and assessing compliance. • Little support in government and sectors of community for this type of regulation.	• Regulations for water storage, effluent management. • Land-use planning that provides effective buffers. • Building guidelines that encourage construction of insect-proof enclosures. • Whole of government approach eg. flu pandemic response.	• Health • Planning • Environment • Cabinet • Local Gov't • Quarantine • Transport • Emergency
Public education and communication			
• Health promotion, disease prevention and health care of migrant populations and travellers. • Public education program regarding the risks associated with living or recreating near vector breeding habitat. • Tailor education materials for specific group needs. • Improved collaboration between the health, planning, agricultural, forestry, environment and conservation sectors on issues influencing vector-borne disease.	I/D D I/D I/D	• Inadequate resources. • Little capacity in agencies to align approaches to support health needs. • Greater investment needed - coordinate with Federal Gov't.	• More resources. • Political acknowledgement and support.	• Health • Local Gov't • Federal • Northern States
Surveillance and monitoring			
• Conducting surveillance of vector density and disease transmission - improved training and resources for this. • Surveillance programs to detect incursions of vectors and diseases through uncontrolled movements of illegal fisherman, refugees. • Ensuring appropriate surveillance and reporting of veterinary diseases and networking with public health agencies. • Improvement of active laboratory-based disease surveillance and prevention systems at the state and local level. • More effective and rapid electronic exchange of surveillance data. • Increased testing for exotic diseases in tourists/ migrants/refugees.	I D D D D I/D	• Inadequate resources and little recognition of increasing threats.	• Regulation and enforcement of disease notification. • Mosquito surveillance and pathogen isolation. • Border protections and increased surveillance of broader range of vectors and hosts. • Rapid response protocols and plans. • Surveillance of exotic arthropod organisms with health impacts.	• Health • Quarantine • Immigration • Industry • Local Gov't • Federal

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard – in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Ecosystem intervention				
• Management of disease vector breeding sites. • Ecosystem diversity and health along with appropriate land-use planning.	I	• Increasing urbanisation may lead to better managed land and reduce vector breeding and harbourage. • Coastal and low-lying communities may be particularly vulnerable, so precautionary land-use planning is critical.	• Man-made sites – design, maintenance and access. • Management of host species and habitat. • Management of agricultural practices. • Quarantine of some locations i.e. 'no go' zones.	• Health • Planning • Environment • Water • Local Gov't • Agriculture • Indigenous Affairs • Industry • Conservation • Community
Infrastructure development				
• Appropriate design to minimise vector breeding potential and on-going requirement for maintenance. • Management of vectors during periods of high risk. • Collaboration between health, forestry, environment and conservation.	D I	• Training for designers and planners must include awareness of vector-borne disease.	• Adapt building codes to ensure protection of people from vectors. • Infrastructure design must not create or exacerbate vector breeding. • Whole of government approach is required.	• Health • Forestry • Environment • Planning • Local Gov'ts
Technological or engineering				
• Developing selective and sustainable vector control, including preparedness for emergency control. • 'Over-design' engineering to allow for extreme events. • Contingency planning for allowing access of emergency personnel and equipment to isolated regions. • Road design that does not pool water. • Building design that excludes rodents.	I			• Transport • Planning • Housing • Local Gov't

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard – in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Health intervention				
• Ensuring early diagnosis and prompt treatment of dengue haemorrhagic fever. • Ensuring early diagnosis and prompt treatment of other vector-borne diseases. • Decentralised facilities – quarantine and disease response and testing. • Provision of more doctors with appropriate awareness. • Vaccine development.	I D	• Capacity variable, depending on training of health professionals in GP surgeries, hospitals and quarantine/ refugee facilities. • Vaccine development needs long-term support and funding of researchers and programs.	• Education of GPs and health authorities. • Increase public awareness. • Cross links with other States, Commonwealth and countries.	• Health • Quarantine • Local Gov't • GPs

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 12b: Vector-borne diseases: research/information requirements

Research/Information	Capacity*	Sectors
• Assessment of current effectiveness of vector control measures. • Studies of transmission dynamics, including reservoir host and vector ecology. • Improvements in epidemic forecasting. • Research into improved treatment and diagnosis of vector-borne diseases. • Research into development of vaccines. • Influence of human population shifts in next 30 to 50 years on vector-borne diseases. • More accurate projections on climate change impacts likely to influence incidence – e.g. rainfall in northwest. • Cost-benefit analysis to assess the value of the intervention/ monitoring programs. • Quantitative risk assessments on a regional basis. • Regional assessments of health issues and identification of vulnerable groups. • Likelihood of exotic mosquito incursion. • Vector competence of our Anopheles species for malaria transmission. • Vector competence of native mosquitoes for exotic pathogens. • Natural control mechanisms – competition between dengue mosquito and native species in container habitats.	All I/D	• Health • Local Gov't • Research • Federal • Bureau of Statistics • Quarantine • Other countries • Immigration

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 13a: Key component 5 - air quality and associated health impacts: respiratory illnesses, asthma, allergies, UV radiation, VOC exposure, Légionnaires disease

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Development and enforcement of air quality standards. • Vehicle inspection programs. • Land Management. • Local Government implementation and education. • Sealing roads in regional and remote areas and communities. • Consideration of the variability across regions. • Ability to control activities relating to air quality in times of high risk (traffic, industry, fires). • Indoor air quality standards required.	D ? D I/D D/A D I	• Under review which is needed. • Dust related to non-human causes can't be controlled as well. • Dust abatement programs.	• Standards under review. • Smog alerts and how to modify behaviour.	• Environment • Health • Planning • Local Gov't • Transport
Public education and communication				
• Bushfire/control burn pollution – health warnings. • Smog alert warning systems and response plans. • Public education on benefits to air quality of reducing car use, wood fires. • Public education on potential risks of Legionnaire's Disease from poorly maintained evaporative air conditioners and use of water-conserving garden products. • UV monitoring and advisory schemes. • Tailor education programs for specific groups.	D I I A A	• Can be improved eg prescribed burns. • Need more warning. • Existing but can be improved. • Currently being done. Increase as required. • Good education programs in place. Continue to improve - beware of complacency. • Greater investment needed - coordinate with Federal Gov't.	• Ways to inform at risk groups eg publish when going to happen. • Better education in outlets of garden products - facemasks sold with the products.	• Environment • Health • Education • Community • Research • LG's
Surveillance and monitoring				
• Increased monitoring of air quality. • Surveillance of air pollutants of concern during high risk times (city ozone in heat events, fires). • Analysis of primary health care morbidity data, hospital admissions, emergency attendance. • Monitoring of seasonal patterns of respiratory disease. • Use of 'sentinel' populations in different regions, particularly vulnerable groups. • Pollen monitoring.	A I ? ? I I	• Adequate at present. • Air pollutants of concern need more monitoring.	• Review monitoring program. • Need more systematic integration and analysis of data. • Question of resources.	• Environment • Health • Research • Agriculture

Possible adaptation measures	For each potential adaptation measure:		Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?	How can this measure be implemented or upgraded in WA?	
Ecosystem intervention			
• Control burning to reduce risk of major fires. • Fire break management. • Provision of natural shade for UV protection. • Weed management programs. • Revegetation to control dust.		• Could need to review and monitor for unintentional effects especially if increase in burning. • Need to consider in urban areas of infill and high density.	• Environment • Conservation • Local Gov't • Agriculture
Infrastructure development			
• Incentives to reduce air pollutants. • Reduce reliance on cars in Perth. • Increased shaded areas in cities and public places. • Renewable energy infrastructure needs to be increased. • Government contributions and incentives for improved public transport, hybrid cars etc.		• Need to improve. • Needs greater Gov't investment.	• Expand wood heater buy back scheme. • Implement Network City.	• Planning • Environment • Energy • Local Gov't
Technological or engineering			
• Development of innovative transportation approaches to reduce air pollution. • Reducing emissions from range of sources. • Urban weather modeling of conditions of inversions in urban weather. • Improvements in UV resistant materials and UV protection. • Incentives to use green power. • Support for R&D and implementation. • Development of low VOC materials. • Better urban/housing design to reduce air pollution.		• For all points - need to increase.	• Will require further resources. • Collaborative approach.	• Planning • Industry • Resources • Research
Health intervention			
• Improved diagnosis and medical treatment for the range of potential health impacts related to air quality and UV exposure. • Increased recognition of the possible links between climate change, air quality and health impacts. • Sunscreens, eye protection.		• Need improvement for all.		• Health • Research

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 13b: Air quality and associated health impacts: Research/information requirements

Research/Information	Capacity*	Sectors
• Relationship between air pollutants and climate parameters (eg ozone levels may be affected by cloud cover and wind speeds). • Coordination with IOCI on obtaining information about the critical climate parameters. • Health impacts of long-term exposure to high levels of ozone, particularly for vulnerable groups. • Regional assessments of air quality health issues and identification of vulnerable groups. • Health impacts of possible increased exposure to dust. • Mechanisms of adverse health effects of air pollutants in the general population and within susceptible subgroups. • Moderating the impact of air pollution on health through nutrition and other lifestyle characteristics. • Better understanding of potential health impacts of increased air conditioning use and increased time indoors. • Better understanding of the role of aeroallergens in respiratory morbidity. • Better understanding of the relationship between temperature, behavioural changes and UV exposure.	All I/D or N	• Health • Research • Environment • Climate • Research • Indigenous communities

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 14a: Key component 6 - food-borne disease: food poisoning, seafood poisoning, mycotoxins

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Food safety regulations. • Agricultural regulations.	A A	• FSANZ - food standard codes considered good.	• Enforcement of regulations is main issue. • Adoption of the new Food Bill.	• Health • Agriculture • Fisheries
Public education and communication				
• Increased education campaigns on food safety, nutrition and hygiene, particularly in warmer months. • Tailor education materials for specific groups.	I	• Training programs. • Greater investment needed - coordinate with Federal Gov't.	• Need to target campaigns to high risk periods. • Need to expand spread of general public education.	• Health • Education

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Surveillance and monitoring				
• Increased monitoring/surveillance of food poisoning, particularly in high risk periods. • Increased monitoring/surveillance of ocean temperatures and incidence of marine toxins - Ciguatera. • Monitoring of pathogens in aquaculture/ fisheries in areas of risk of contamination during extreme rainfall events. • Monitoring of mycotoxins, particularly in high risk periods. • Enhancement of collaborations across health, agriculture, fisheries. • Fisheries practices.	A A A I D A	• OzFood Net- strong role in monitoring. • Outbreak Register. • Communicable diseases.	• Increase resources as necessary. • Local Government resources are critical. • Continue cross-sectoral programs between fisheries and health.	• Health • Fisheries • Agriculture
Ecosystem intervention				
• Protection of wetlands and natural habitat surrounding fisheries. • Protection of natural habitat surrounding agricultural land.	? ?			• Environment • Fisheries • Agriculture • Planning
Infrastructure development				
• Improved food storage facilities including in remote areas.		• Greater investment needed - coordinate with Federal Gov't. • More inspections by Local Gov't.	• Link to Outback Stores program of Federal Gov't.	• Local Gov't • Indigenous communities
Technological or engineering				
• Improved food storage methods, particularly in remote communities. • Improvements in farm storage methods. • Control of sewerage treatment near aquaculture and fisheries, particularly in extreme events. • Development of independent power sources in remote communities.	D D D D	• Current programs for small communities need to be expanded. • Remote Renewable Power Generating Program.		• Energy • Housing • DIA • Water • Local Gov't
Health intervention				
• Standard medical treatment. • Improve community awareness. • Greater involvement of Environmental Health Officers (EHOs).	A D	• Main problem is access to appropriate treatment. • More EHOs and health workers in remote areas.	• Link to EHO programme including those for remote communities. • Link to Indigenous Health Worker training programmes.	• Local Gov't • Indigenous communities

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 14b: Food-borne disease: research/information requirements

Research/information	Capacity*	Sectors
• Data collection examining potential links between climate parameters and food poisoning – identification of organisms likely to proliferate under new climate conditions. • Emergence of new food-borne pathogens in WA. • Research into impacts of behavioural changes (more outdoor eating) on incidence of food poisoning. • Emergence of new marine organisms with health impacts. • Regional assessments of health issues and identification of vulnerable groups.	All I/D	• Health • Food • Fisheries • Health • Quarantine • Agriculture

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 15a: Key component 7 - food production: prices and availability, fall in quality of diet, imported food health risks

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Integration of climate change and health considerations into food import and regulatory activities. • Control on water use to maximise efficient use during food production. • Controls on water reuse for food production. • Potential impacts of climate change incorporated into national food and nutritional policies. • Mechanisms to support equitable prices and access to nutritional foods, especially in remote communities. • Risk assessments of food imports and local foods need to be undertaken with climate change considerations. • Consideration of food kilometres.	I I/D D I I I/D I	• Current regulations are adequate but need to build-in climate change considerations domestic and imported food.	• Enforcement of legislation. • Monitor imported food.	• Agriculture • Quarantine
Public education and communication				
• Education regarding nutritional standards. • Education programs for primary producers on potential impacts of climate change on agricultural practices.	D I	• Continuation of nutritional programs.	• Increase spread of programs. • Improve programs targeting healthy diet on low incomes.	• Health • Agriculture

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard – in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Surveillance and monitoring				
• Monitoring of crop yields. • Monitoring of crop water efficiency. • Monitoring of nutritional content of foods. • Monitoring of food prices and affordability, especially in relation to climate and extreme events. • Monitoring of imported food levels. • Increased surveillance and monitoring programs for food safety in imported foods. • Monitoring of potentially emerging contaminants such as mycotoxins. • Monitoring of antibiotic use in animal feed that may increase due to higher heat stress, particularly with imported foods. • Alternative strategies for monitoring increased level of imports – need more than end-product testing.	A ? A I I I I ?	• Agricultural monitoring ok. • FSANZ currently monitor nutritional content. • Food basket surveys monitor costs. • Monitoring of food prices, availability and nutritional content especially in remote and indigenous communities.		• Agriculture • Health • Welfare
Ecosystem intervention				
• Conservation measures for natural habitat.	D/I		• Improve incentives for conservation of natural habitat.	• Environment • Conservation • Agriculture
Infrastructure development				
• Development of long-term strategic plans for agriculture. • Land-use- appropriate agricultural precincts in urban areas.	D/ ID	• Beginning in some regions eg Avon Basin Plan. • Inadequate in many areas.	• Need more expert advice and long-term outlooks.	• Agriculture • Climate • Water • Planning
Technological or engineering				
• Diversification of agriculture. • Drought-resistant, pest-resistant crops. • Improvements in crop yield modeling. • Improvements in shelf-life especially for remote communities. • Post-harvest strategies for fresh food and seafood. • Encourage systems for producing own food.	D D D	• On-going research in agricultural sector.	• Expand research and collaboration between sectors.	• Agriculture • Fisheries
Health intervention				
Not Applicable				

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 15b: Food production: research/information requirements

Research/information	Capacity*	Sectors
• Relationship between climate change – extreme weather events, rainfall and temperature changes on the cost and availability of locally grown food. • Alternative crops. • Drought resistant crops. • Pest resistant crops. • Sustainable crops. • Assessment of regional agricultural vulnerability. • Research into alternative foods and development of independent food sources. • Acceptability of alternatives. • Relationship between availability and food standards (scarce food – quality level drops).	All I/D	• Agriculture • Health • Research • Education

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 16a: Key component 8 - social/community/lifestyle - dislocation, mental health

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard - in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Legislative or regulatory				
• Requirement to disclose regional vulnerabilities to sea-level rise. • Regulations regarding compensation arrangements for forced relocations. • Explore the provision for insurance in areas where private insurance is unavailable. • Issue of risk communication and disclaimers to land purchasers (similar to noise issues or contaminated sites). • Regulatory restrictions on land-use and development in coastal zones. • Shared responsibility – appropriate funding for vulnerable regions and remote communities. • UK – food rule – fresh produce must display place of origin – encourage local production and purchase of food.	I/D N N I D D D	• Bilateral agreements with Indigenous groups. • Strategy for Indigenous groups. • Aboriginal Affairs Planning Authority to be updated.	• Coastal mapping. • Need adequate funding. • Partnership development.	• Resources • Environment • Health • Planning • Local Gov't • Tourism
Public education and communication				
• Raise awareness in coastal regions with respect to future risks of sea-level rise. • Strengthen community resilience and health through community based health programs. • Raise awareness on impacts of climate change and risks in vulnerable regions. • Tailor education materials to meet needs of vulnerable groups. • Education on energy sustainability. • Cross department information sharing. • Taskforce for impacts of climate change on coastal communities. • Open dialogues.	I/D N N N N D D N	• Greater investment needed - coordinate with Federal Gov't. • Coordinate with State Welfare Agency. • Check status of Local Emergency Management Committees.	• Increased public awareness and social movement - community willingness. • Public awareness will begin to influence markets.	• Government as whole • Media • Popular Culture

Possible adaptation measures	For each potential adaptation measure:			Sectors
	What is our capacity* in this regard – in general and for vulnerable regions and groups?		How can this measure be implemented or upgraded in WA?	
Surveillance and monitoring				
• Improvement in monitoring of mental health in rural and remote areas. • Evaluation of mental health care in response to extreme events, especially groups vulnerable to the adverse psychosocial effects of extreme events, such as children, elderly people and bereaved people. • Surveillance programs for agricultural pests and weeds, native flora and fauna and marine environment.	I I D		• Planning – linking data. • Morbidity-mortality. • Health and social data. • Universities working in partnerships with Government departments. • Link with mining companies to provide community funding.	• Health • Community • Agriculture • Resources • Industry • Local Govt • Welfare
Ecosystem intervention				
• Protection of natural habitat. • Education regarding ecosystem impacts and role in health.	I	• Identification of environment as important for people's quality of life.		• Environment • Health • Planning
Infrastructure development				
• Development of healthy communities. • Urban design and investment in infrastructure for social considerations. • Long-term planning for alternative income streams for vulnerable populations. • Long-term planning for communities vulnerable to climate change and depopulation. • Identification of new industries and businesses that may emerge from climate change. • Long-term planning for land-use with respect to sea-level rise and other extreme events. • Develop contingency relocation plans in case of sea level rise and other extreme events. • Regional investment funds (currently in Pilbara). • Support for Local Government – currently not in a position to fund 'partnerships'. • Consider viability of remote Indigenous communities.	D I I D N N D/N I	• Work closer with resource sector to encourage local employment strategies.	• Planning and infrastructure agencies to plan now. • Comprehensive induction of cultural awareness. • Recognition and resources for primary and follow-up care.	• Resources • Environment • Health • Planning • Local Gov't • Tourism
Health intervention				
• More resources for holistic health services and provision of comprehensive mental health services in vulnerable regions. • Training for the potential mental, physical and social health impacts of climate change.				

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

Table 16b: Social/community/lifestyle: research/information requirements

Research/information	Capacity*	Sectors
• Better understanding of the mental, physical and social health effects of extreme events and gradual impacts such as drought, particularly in vulnerable regions.	A	• Universities • CSIRO • IOCI
• Regional assessments of vulnerability to dislocation due to extreme events.	N	• Health • Mental Health Units
• Research into early warning systems for social impacts of climate change.	N	• Community Groups
• Assessment of sea-level rise and extreme weather impacts on coastal communities.	N	
• Policies to protect low income groups from added financial pressures of climate change.	N	
• Population modeling in relation to climate change – health implications of projected population changes.	I/N	
• Research into relationship between temperature, heat events and rates of crime, accidents.	N	
• Community - comprehensive review on impacts on communities and how to sustain and promote healthy communities.	N	
• Consideration of the viability of and investment into remote communities.	N	

* A = adequate, D = developing, I = inadequate, N = not in place, ? = unknown

6. Prioritisation of adaptation responses

The aim of this component of the project was to provide decision makers with an indication of the adaptation responses that need to be considered, together with the priorities of these responses and hence the need for action in the short, medium and long term. Table 17 provides a summary of the Risk Ranking developed by the specialist health and risk assessment group described in section 5.2.1. Table 18 gives the management action for each of the risk ranking priorities. This table is consistent with that described in AS 4360: Risk Management.

Table 17: Risk Ranking summary

Risk	Health impacts arising from:
Extreme	• Extreme events • Heat events • UV exposure • Reduced rainfall and availability of water for food production • Reduced access to health care, food and water • Inability to meet energy demand
Extreme/High	• Fires • Changes to air quality
High	• Flooding • Drinking water contamination • Pathogens in recreational waters • Changes to disease vector distribution and abundance • Exposure to allergens • Food Poisoning • Dislocation • Impacts to Mental Health • Changes to biodiversity • Populations reductions and loss of goods and services
High/Medium	• Pathogens in grey-water/non-potable drinking water
Medium	• VOC Exposure • Exposure to Legionnella spp. • Exposure to Mycotoxins • Exposure to pathogens in food • Exposure to arthropods and other organisms (bites and stings) • Availability and quality of food • Increases in imported foods • Changes to the incidence in crime, accidents, recreational activities, alcohol consumption, self neglect and loss of green space and gardens
Medium/Low	• Sleep deprivation
Low	• Increased pesticide exposure • Increased chemical exposure

Table 18: Management actions for risk priorities

Risk levels for health	Description of management action
Extreme	Risks require urgent attention at the most senior level and cannot be simply accepted by the community.
High	Risks are the most severe that can be accepted by the community.
Medium	Risks can be expected to be part of normal circumstances but maintained under review by appropriate sectors.
Low	Risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

The degree of variation in the current capacity to respond within most of these health areas (as indicated by Adequate, Developing, Inadequate, Not in Place or Unknown in tables 9-16) does not allow for estimates of specific priorities for action within each of the key components. However this process has identified the levels of risk to health based on the severity of potential health outcomes linked to the current capacity to deal with associated climatic variables. Therefore, to provide decision makers with initial guidance on the potential direction for future consideration of the health impacts of climate change in WA, the general adaptations (see table 19) are recommended for consideration through a whole of government approach. The next stage would be consideration of the adaptation measures in each of the separate key components by a lead agency or sector together with other relevant sectors.

Subsequent responses should determine whether each of the proposed adaptations requires further justification and can be implemented readily or if further analysis is required to determine more details about the nature of the risk and hence the most appropriate response actions. Some risks may need to be accepted as given because there is no cost-effective adaptation measure or the risk is considered insignificant.

The process used in this project will need to be repeated, probably in a modified form, as new information on the monitoring of climates parameters, predicted climate changes and the predicted adverse impacts on human health become available.

Table 19a: General principles and adaptation measures

Possible adaptation measures	For each potential adaptation measure:		Sectors
	What is our capacity in this regard - in general and for vulnerable regions and groups?	How can this measure be implemented or upgraded in WA?	
Legislative or regulatory			
• Policy development for a coordinated body to organise adaptation responses. • Integrated assessments of environmental, economic and health impacts of climate change. • Integrated assessments of environmental, economic and health impacts of climate change mitigation and adaptation measures. • Incorporate adaptation measures into long-term policies and action plans. • Cost sharing mechanisms for compensation and adaptation initiatives. • Need for coordination through whole of government approach. • Coordination and integration with the State Sustainability Strategy. • More prominence to health impacts. • Need to set up coordinated funding to assess and implement appropriate adaptations. • Need to develop a long-term approach to reducing the risks of climate change (bipartisan support).	• Office of Climate Change. • Premier's Climate Change Action Statement - publicity and development needed. • Sustainability Unit.	• Need involvement of all sectors. • Regulations that ensure climate change is taken into account. • Legislation/ regulation must effectively change individual and company behaviour. • The Office of Climate Change and the Sustainability Unit need to be appropriately resourced.	• All of Government
Public education and communication			
• Increased awareness of links between climate change and health. • Increased awareness of adaptation. • Education programs targeted specifically for vulnerable groups (EG ESL, children, Indigenous communities etc). • Upgrade current education and communication programmes. • Web resources - need development, needs to be populated with information. • Need a central coordinated government sanctioned information source. • Improved community engagement processes with a partnership approach among communities, government and industry.	• Act Now for the Future climate change website.	• Greater investment needed - including coordination with Federal Gov't Communications must provide advice on how individuals and companies can change behaviours.	• All of Gov't
Surveillance and monitoring			
• Monitoring of climate parameters. • Monitoring of environmental changes and their links to communities. • Monitoring of health impacts. • Monitoring of population changes. • Monitor early impacts of health changes around the world. • Monitor adaptations and technologies being implemented elsewhere and assess for relevance in WA.	• IOCI and BoM	• Need for surveillance and monitoring across a range of sectors.	• All of Gov't

Possible adaptation measures	For each potential adaptation measure:		Sectors
	What is our capacity in this regard - in general and for vulnerable regions and groups?	How can this measure be implemented or upgraded in WA?	
Ecosystem intervention			
• Conservation and biodiversity measures to retain or restore ecosystems.			• All of Gov't
Infrastructure development			
• General improvements in public health infrastructure and resources. • Long term assessment of infrastructure needs. • Financial consideration of the long-term economic impacts of infrastructure spending due to climate change. • Establish methods of cost-sharing where economic burdens are high.	• Coordination with Federal Gov't	• Budget planning for long term Infrastructure development.	• All of Gov't
Technological or engineering			
• Solutions to withstand new climate parameters. • Solutions to prevent or reduce risk of health impacts from climate change. • Solutions to improve access and affordability of adaptation measures. • Application of new technology for scientific measurement (eg vector borne disease, water quality, climate change etc).		• Greater investment in R&D State and Federal Gov'ts Cooperation with industry and universities.	• All of Gov't
Health intervention			
• Improved medical access for remote communities and vulnerable groups (eg elderly, obese, disabled). • Improved education and awareness of health professionals of links between health and climate. • Understanding of the risk for the emergence of new, unfamiliar diseases and health impacts. • Better regional treatment facilities with provision for emergency services. • Greater resources for public health and environmental health officers and emergency management.		• More EHOs in remote areas.	• All of Gov't

Table19b: General principles and adaptation measures – research/information requirements

Research/ Information	Capacity	Sectors
• Regional Assessments – Identification of vulnerable groups, areas and infrastructure (aviation, roads and rail). • Regional Adaptation Plans. • Status of implementation of *Emergency Management Act*. • Links of Emergency Management to State Influenza Pandemic Plan • Sustainable adaptation. • Quantitative assessments where practicable. • Improved climate projections. • Understanding the links between climate parameters and health impacts. • Strong collaboration/communication between health and climate scientists. • Evidence of effects of climate change that may impact on health. • Cost-benefit analysis of adaptation measures. • Assessment of the affordability of adaptation measures – especially in relation to low income groups. • Assessment of coincidental costs and benefits to health of adaptation and mitigation. • Evaluation of adaptation options within a risk management approach. • Impact of carbon trading and credits on emission reduction.		• All of Gov't • Other research sectors • NGOs • Industry

7. Discussion and conclusions

This report identifies many potential adaptation measures to reduce or mitigate the impact of climate change on human health in the community of WA. The possible events which could impact on health have been identified in terms of the estimated Level of Risk and the estimated level of capacity response currently in place. The risks from climate change will be different from one sector to another and hence a more detailed assessment on a sector by sector basis will be needed. This detailed assessment should allow sectors to make judgements about the risks that need some attention in the short term, those that can be set aside for later attention and those where more information is needed. The results are expected to be used by decision makers to provide direction as to how planning should proceed in the short, medium and long term.

A major problem of this exercise was dealing with the significant uncertainties at each stage of the process used in this investigation. Typical quantitative risk assessment procedures rely on well documented risks and with the availability of adequate data, reasonably good risk estimates can be calculated. Trying to make judgements about risks to human health from interacting climatic variations and consequential environmental changes is much more difficult because of the degree of uncertainty that exists. In addition to this there were uncertainties about the proposed adaptations in tables 9-16 as workshop participants were not necessarily aware of the status of the current specific situation for each of the proposed adaptation measures for reducing health impacts in WA. In the final analysis it may be that some risks will need to be accepted because there is no cost effective adaptation measure or the risk to human health is considered to be insignificant in WA.

The level of risk assessment used in this project did not require a detailed understanding of climate change to provide a general indication of the types of adaptation responses needed to reduce the adverse effects on health which may arise. However, further information is needed in order to progress to a more detailed and accurate assessment of current adaptation measures. The activities and requirements of specific sectors will need a greater level of general awareness and increased capacity to scientifically predict the impacts of climate changes on health and to develop and implement further effective adaptation strategies.

To support this there needs to be improvement in environmental and health monitoring and surveillance systems in the different parts of WA. Various sections in the health care sector could provide a low cost monitoring mechanism for specific vulnerable groups and hence sentinel data. Although this project has identified many potential adaptation responses for WA relatively little is known about the potential barriers to and opportunities for the introduction of the various adaptation strategies and their cost effectiveness. Thus there is the need for more research into these issues. These processes also need to be linked with work being done on the topic by other organisations such as IOIC, CSIRO etc.

Recent increased awareness of changes in the climate and the potential impacts this may have on our health and way of life have resulted in an increased interest and concern about mitigation of adverse effects and as well as the implementation of adaptation measures to reduce adverse impacts. As more information becomes available from scientists and other specialists, it is clear that adaptation strategies need to be formulated for all sectors including health.

The extent of impacts from adverse effects will depend on how well society can estimate the level of the impacts, the planning processes for adaptation strategies and the successful implementation of the adaptation measures. Concurrent with these processes will be measures to mitigate the changes in the various climatic parameters which can result in environmental impacts.

It is accepted that climatic conditions in WA are changing and that there will be physical and environmental changes to WA that will influence the way we live. Decision makers in WA are currently addressing possible mitigation mechanisms to support the global requirement to reduce greenhouse gas emissions and other causes of climate change. It has also been recognised that adaptations to protect communities and support social environments are necessary.

This project has identified health impacts and a range of adaptations that could be implemented across WA which can form the basis for future climate change responses by decision makers to protect community health.

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Glossary

Adaptation	Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, public and private adaptation, and autonomous and planned adaptation.
Adaptive Capacity	The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Algal Blooms	A reproductive explosion of algae in a lake, river, or ocean.
Allergens	Antigenic substances capable of producing immediate-type hypersensitivity.
Anthropogenic	Resulting from or produced by human beings.
Arbovirus	Any of various viruses transmitted by arthropods.
Biodiversity	The numbers and relative abundances of different genes (genetic diversity), species, and ecosystems (communities) in a particular area.
Biofuels	A fuel produced from dry organic matter or combustible oils produced by plants.
Carbon Dioxide (CO_2)	A naturally occurring gas, also a by-product of burning fossil fuels and biomass, as well as from land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.
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 of years. The classical period is 3 decades, as defined by the World Meteorological Organization (WMO). 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.
Climate Change	Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Coping capacity	The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards.
Cryptosporidiosis	An opportunistic infection caused by an intestinal parasite common in animals. Transmission occurs through ingestion of food or water contaminated with animal faeces. The parasite causes severe chronic diarrhoea
Drought	The phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.
Environmental Health	Those aspects of human health determined by physical, chemical, biological and social factors in the environment. Environmental health practice covers the assessment, correction, control and prevention of environmental factors that can adversely affect health, as well as the enhancement of those aspects of the environment that can improve human health.
Extreme Weather Event	An event that is rare within its statistical reference distribution at a particular place. By definition, the characteristics of what is called "extreme weather" may vary from place to place. An "extreme climate event" is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g., rainfall over a season).
Hazard	The capacity of an agent to produce a particular type of adverse health or environmental effect.
Health	Health is a state of complete physical, mental and social well being and not merely the absence of disease or infirmity (World Health Organisation (WHO), 1946).
Health Impact Assessment	A systematic process to assess the actual or potential, and direct or indirect, effects on the health of individuals, groups or communities arising from policies, objectives, programs, plans or activities.
Health Risk Assessment	The process of estimating the potential impact of a chemical, biological, physical or social agent on a specified human population system under a specific set of conditions and for a certain time-frame.
Impacts	Consequences of climate change on natural systems and human health. Depending on the consideration of adaptation, we can distinguish between potential impacts and residual impacts: • Potential impacts are all impacts that may occur given a projected change in climate, with no consideration of adaptation.

- Residual impacts are the impacts of climate change that can occur after adaptation.

Infrastructure	The basic equipment, utilities, productive enterprises, installations, and services essential for the development, operation, and growth of an organization, city, or nation.
Risk	The probability that, in a certain timeframe, an adverse outcome will occur in a person, group of people, plants, animals and/or the ecology of a specified area that is exposed to a particular dose or concentration of a hazardous agent i.e. it depends on both the level of toxicity of the agent and the level of exposure.
Sea-Level Rise	An increase in the mean level of the ocean.
Sensitivity	Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).
Vector	An organism, such as an insect, that transmits a pathogen from one host to another.
Vector-Borne Diseases	Disease that is transmitted between hosts by a vector organism (such as a mosquito or tick).
Vulnerability	The degree to which a system is susceptible to, or unable 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 variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Appendix one: Checklist for identification of potential impacts

Category	Potential impacts
Direct effects	• Heat Stress • Physical Injury/Death from extreme events
Physical effects	• Flooding • Storms/wind • Tropical cyclones • Lightning strikes • Soil Erosion • Droughts • Bushfires • Frosts • Hail • Rain
Environmental factors	• Air quality • Water quality • Soil quality • Food contamination • Radiation • Waste-water • Pathogens • Vector-borne disease factors /Vermin • Water-borne diseases • Broader environmental issues (CO_2 emissions) • Food Production - crops and animals • Nuisance - noise, odour • Health and safety at work • Visual amenities (green space, coastline)
Ecological factors	• Loss of habitat • Impacts on plant diseases, pests, weeds • Physical changes to land - coastline, rivers • Changes to groundwater levels • Flora and fauna - change in distribution
Socio-economic factors	• Employment • Access • Social network • Local Business • Economic Issues • Crime • Housing • Population Changes
Psychosocial factors	• Mental Health Issues • Choice • Community • Status • Social Conflict • Others
Lifestyle factors	• Exercise • Diet • Health behaviour • Alcohol/Drugs • Others

Category	Potential Impacts
Technological factors	• Accidents (mechanical, chemical etc) • Fire, explosions • Waste Treatment
Services	• Resource availability • Access to emergency services • Routine access to health services (primary/secondary) • Routine access to other services (schools, shops, transport)

Appendix two: risk assessment process

Objective:

To obtain a qualitative assessment of potential health impacts of climate change identified in Phase One.

Method

Groups of two to three participants considered two to three areas of interest. Each health impact was assessed in terms of consequences and likelihood. Results were entered into a risk matrix to arrive at a risk priority level.

Consequence x Likelihood = Risk Priority Level

Two important assumptions for the assessment were:

3) The year is 2030 and climate change projections have occurred.
4) Only current controls for each health impact are taken into account.

Consequence rating

The consequences of potential health impacts were considered in terms of the magnitude of the impact. This can be judged by the severity of the health impact, the number of people affected, the duration of the impact and the socio-economic implications. Ratings were made according to the table below.

Consequence	Examples
Catastrophic	Large numbers of serious injuries, illnesses or loss of life. Severe and widespread disruption to communities. Long term inability to deliver essential goods and services. Severe long-term reductions in quality of life. Huge economic costs.
Major	Small numbers of serious injuries, illnesses or loss of life. Significant, widespread disruption to communities. Significant decline in delivery of essential goods and services. Significant long-term decline in quality of life.
Moderate	Small number of minor injuries or illnesses. Significant disruption to some communities. Significant decline in delivery of essential goods and services. Significant short-term or minor long-term reduction in quality of life.
Minor	Serious near misses or minor injuries. Isolated short-term disruption to some communities. Isolated but significant reductions in essential goods and services. Minor reductions in quality of life.
Insignificant	Appearance of a threat but no actual harm. Very minor disruption to small section of community. Isolated, minor reduction in delivery of essential goods and services. Insignificant impacts on quality of life.

Likelihood rating

The likelihood of the health impact occurring was then assessed as follows

Likelihood	Description
Almost certain	Is expected to occur in most circumstances.
Likely	Will probably occur in most circumstances.
Possible	Might occur at some time.
Unlikely	Could occur at some time.
Rare	May occur only in exceptional circumstances.

Risk priority levels

Results from consequence and likelihood assessments were entered into the risk priority matrix to give an initial risk priority level.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Evaluation

Risk priority levels from each group were compared. If levels differed, further discussion and comparison of the relative risks was carried out and a risk priority level agreed upon. When all priority levels were collated, they were reviewed as a whole and risks considered to have been over- or under- rated were adjusted. Mixed ratings, such as high/medium were assigned as deemed necessary.

Appendix three: Participants and reviewers

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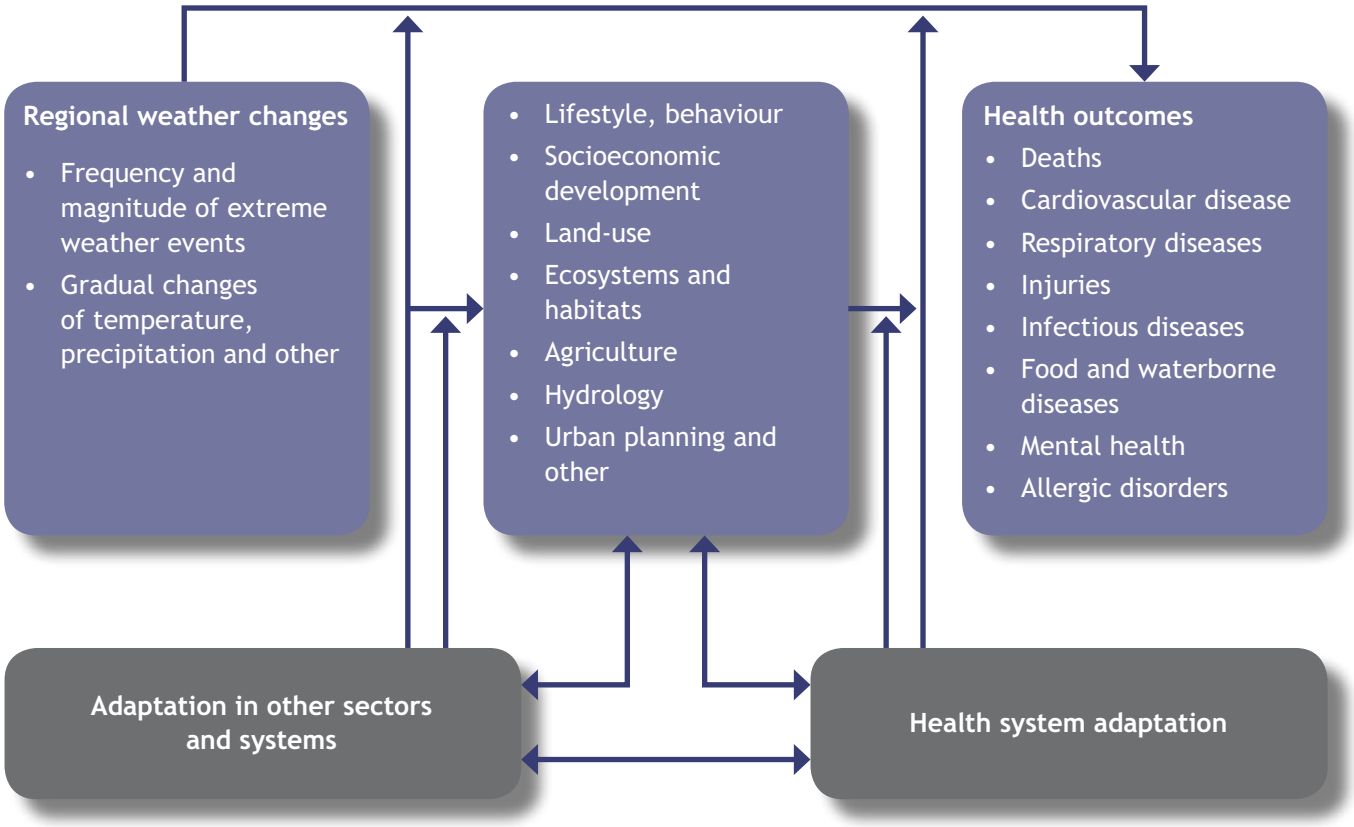
Regional weather changes
Frequency and magnitude of extreme weather events
Gradual changes of temperature, precipitation and other
Lifestyle, behaviour
Socioeconomic development
Land-use
Ecosystems and habitats
Agriculture
Hydrology
Urban planning and other
Health outcomes
Deaths
Cardiovascular disease
Respiratory diseases
Injuries
Infectious diseases
Food and waterborne diseases
Mental health
Allergic disorders
Adaptation in other sectors and systems
Health system adaptation

(WHO, 2005)


Prerequisits of adaptation
• Linkage between health and climate.
• Capacity building.
• Strenghtening of existing and overcome obstacles.
• Share lessons accross sectors and countries.
• Revise standards.
• International solidarity.
• Local solidarity.
• Communication.
Health sector adaptation possibilities
• Implement effective responses to early warning.
• Strenghten health system peparedness.
• Risk management.
• Strenghten disease surveillance and health protection measures.
• Vector and host control.
• Awareness raising and education.
• Treatment and vaccination.
Health driven adaptation-mitigation necessities
• Land - use change.
• Urban planning.
• Housing improvement.
• Structural and non-structural measures.
• Transport, energy and agriculture policies.
Increasing "adaptability"
• Reducing inequalities.
• Investment in health protection and prevention.
• Achieving/maintaining highest levels of health care coverage.
• Access to information and technology.

(WHO, 2005)

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