

Climate change challenges to health

Risks and opportunities

RECOMMENDATIONS FROM THE 2014 THEO MURPHY HIGH FLYERS THINK TANK



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The purpose of the Theo Murphy High Flyers Think Tank series is to bring together early- and mid-career researchers from a broad range of relevant disciplines to engage in thinking about novel applications of existing science (including social science) and technology to issues of national significance, and to identify gaps in knowledge that should be addressed. These annual events are a unique opportunity for career development and networking among the nation's next generation of research leaders and their institutions. Think Tanks are one of the premier events of the Academy's calendar; this is the 13th hosted by the Academy.

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Executive summary

By the end of the century, global temperatures are likely to have risen by at least 2°C compared with pre-industrial times. No nation will be immune to the resulting changes in the world's weather patterns and as international negotiations aimed at reducing future carbon emissions continue to have limited success, it would be rash for any country to fail to plan to meet the consequent challenges to their infrastructure and citizens. For Australia, one of the most important concerns is the health of its people.

This report summarises the discussions and recommendations of a group of early- and mid-career researchers from a broad range of relevant disciplines who came together in July 2014 to consider climate challenges in relation to health in Australia. Five main impacts were considered.

1. **Extreme weather events.** These include heatwaves, droughts, storms, cyclones and floods. These will have direct impacts on lives, homes and communities, and will also place stress on the mental wellbeing of members of the community during prolonged events such as intense heatwaves.
2. **Disease.** Many diseases are likely to spread and increase in incidence as the climate warms. A growing human population with high rates of interconnectedness is also at risk from newly emergent and exotic diseases for which we have no treatment or immunity.
3. **Food and water.** Disrupted supplies of water and high temperatures will stress crops and promote algal blooms in reservoirs while rising ocean acidification will affect fisheries.
4. **Jobs.** Livelihoods—including farming, fishing and tourism—will be particularly badly affected from soaring temperatures, droughts and storms. Employment patterns will be changed and disruptions to supply chains will threaten businesses.
5. **Security.** Threatened food supply chains, changing patterns of infectious diseases, and forced migration from land rendered uninhabitable will trigger tension, unrest and violent conflict.

The report also makes it clear that those who suffer the worst effects of climate change will, in general, be the most vulnerable members of society—in particular, the sick, the elderly, the very young and the poor. Others at

risk will include pregnant and breastfeeding women and those who are socially, culturally or linguistically isolated. Research should therefore be enhanced to increase our knowledge about climate change's most likely victims and to improve management solutions aimed at helping them. There is a lack of information about less visible minority groups including the homeless, drug users and migrant groups, and this should be addressed. Information of this kind could help create a portfolio of research that can be used to improve the overall wellbeing of Australia.

Many of the concerns addressed by the different groups who produced the report have considerable overlap. The issues of disease and food and water supply provide an example of this intertwining. Rising temperatures will promote pathogen dispersion and algal blooms in water supplies. Food quality and safety will also be affected directly and indirectly by increasing temperatures, potentially changing the nutrient content of food and increasing the cost and complexity of ensuring safety standards. Adverse impacts on food production will then lead to higher prices and reduced access to nutrition, particularly in disadvantaged or remote communities. This, in turn, will make individuals more vulnerable to disease, in particular to new pathogens that might be spread by vectors, such as mosquitoes that thrive as temperatures rise.

There should therefore be a commitment to create more interdisciplinary approaches in the development of our knowledge about climate change and its many interconnected impacts on Australia and the health of Australians. Key issues that should be covered include poverty, migration, conflict, jobs, security and demographic change as well as specific forecasts about likely physical outcomes, including particular types of pathogens that may affect the country, and the effect of climate change on water supplies. Another important concern for the authors was the need to address how expert advice can best be communicated to governments and their agencies and to the broader community.

The impact of climate change in Australia is likely to vary considerably according to region. Drier conditions are expected to prevail in the southern half of the continent, affecting water supply in cities. Reduced rainfall is also likely to affect Australia's food bowl, the Murray–Darling Basin, which may become more susceptible to pests, crop diseases and reduced

water quality and volume. In addition, rising ocean temperatures and acidity will irreversibly damage key marine ecosystems, including coral reefs, and affect fisheries. Regional food security issues will therefore have implications for Australia.

Internationally, threats to human security and population health will be magnified in low-income countries that are more vulnerable to climate change effects, for example Pacific Island nations. Problems will include erosion of livelihoods; food insecurity; sea-level rise; extreme weather events; increased risk of rivalry and violent conflict within other nations; and migration and population displacement caused by depletion of resources and degradation of ecosystems required to sustain life.

Australia has an important role to play in the Asia-Pacific region, and will not be able to insulate itself completely from the effects of climate change on its neighbours. In such circumstances, Australian military personnel may become engaged in foreign conflicts, peacekeeping operations and humanitarian missions, with risks to their physical and mental health. Research into the determinants of peace and how to avoid conflict could be strengthened and allow Australia to play a constructive role in the region without endangering its military personnel.

Major recommendations

The five different groups of experts involved in writing this report made a total of 22 recommendations. They are listed throughout the document and combined below as eight high-level recommendations. All the recommendations should be examined in the context of the evidence provided in each section; they are put forward as being critical in ensuring Australia is properly prepared for the challenges that climate change will pose to the nation's health.

1. IDENTIFY THE VULNERABLE

A clear message highlighted by all the groups was that some people in Australia will be more vulnerable to the effects of climate change than others. The ill and frail are at particular risk from heatwaves, for example, while poor and socially deprived individuals may suffer disproportionately from disruption to water and food supplies, particularly in remote areas and among socially diverse communities. Establishing systems to monitor the health of these individuals should be considered a priority. This process should also focus on understanding the factors that lead to people becoming vulnerable to climate-related health effects in the first place. This will help define and implement

appropriate long-term strategies to deal with the future impacts of climate change.

2. COORDINATE ALL PREPARATIONS

There should be a coordination of assessments of the different threats posed by climate change and also the nation's responses to them. In particular, there should be a properly established research agenda that focuses on the various ways that climate change will affect the nation, especially the frail and elderly.

3. GET THE MESSAGE ACROSS

In addition to coordinating research programs, there should be an improvement in communication about the dangers that lie ahead and about the need to take actions to avoid specific threats. Early warning systems for various risks (bushfires, floods, droughts) should be coordinated and an understanding gained into why some people choose to ignore warnings. In addition, basic education should be improved in order to achieve broad support for future long-term strategies adopted by the government to counter the effects of climate change.

4. SHAPE THE RESEARCH

More interdisciplinary approaches into the development of our knowledge about climate change should be created in order to help understand the various ways that it will affect the health of the nation. Key issues to be covered should include poverty, migration, conflict, jobs, security and demographic change.

5. CHANGE DIRECTION

There should be a reversal of the downward trend in public investment in agricultural extension and in relevant research and development. High priority should be given to establishing a Food and Water Commission, which would plan for control of future health problems related to food and water, and to setting up an Australian Centre for Disease Control. The latter would unify surveillance, coordinate responses and direct research initiatives in relation to new diseases that will affect the country as global warming takes effect. National coordination is key in these areas. The incorporation of climate-health issues into community development and building design should also be tackled.

6. OPEN UP THE DATA

Mechanisms should be put in place to make it easier to access information. At present there are long delays in acquiring mortality data—for example during heatwaves—which hampers emergency responses

and also slows down the development of long-term strategies. In addition, a great deal of health, agricultural and water data is not made available online at present, and is often insufficient for comprehensive analysis. Proper access, linkage and coordination of such information are vital for the future.

7. CUT EMISSIONS

The potential impact of climate change on human health will require complex responses from society—which reinforces the need for Australia to pursue the

goal of national and international reduction of emissions of greenhouse gases.

8. ENCOURAGE SELF-DETERMINATION

There is no need to wait for the government to act. Individuals, communities, local councils, schools, universities and others should be encouraged to take early action to identify those vulnerable to climate change in their area and support them. In this respect, social media could play a critical role in the future.

Introduction

PROFESSOR BRUCE ARMSTRONG, DR GRAEME PEARMAN

Over the past 250 years, humanity has released about half a trillion tonnes of carbon into the atmosphere by burning fossil fuels. As a result, carbon dioxide levels have risen by 40%. In turn, more heat has been trapped in the atmosphere producing a global warming of around 0.8°C. It is anticipated that over the course of the next few decades, if nothing changes, a further half trillion tonnes of carbon will be released from Earth's growing numbers of factories, cars, trucks, power plants and homes. The consequent rise in global temperatures will almost certainly be more than 1°C.

By the end of the century, global temperatures will have risen by at least 2°C compared with pre-industrial times. At worst, this could result in the thawing of Arctic tundra, releasing plumes of the greenhouse gas methane that are currently trapped there, while dwindling polar ice caps will be unable to reflect solar radiation back into space. In such scenarios, further temperature increases are inevitable with potentially catastrophic rapid feedback effects.

No nation will be immune from the effects of this global temperature rise. Current climate talks that aim to limit future carbon emissions have had little success to date. It would therefore be rash for any country to fail to anticipate future rising temperatures or to neglect to begin preparations to meet the consequent challenges—for these will be considerable. As the world heats up, ice caps will melt and ocean levels will rise, ultimately inundating coastal regions across the planet. Most of the world's population lives close to the sea and many people there face losing their homes and livelihoods. At the same time, many key agricultural regions are like to dry up while increases in ocean acidification are likely to disrupt fisheries. Food supplies will be badly affected.

The world therefore faces a future in which billions of people will be hungry or homeless or both and no nation will be able to avoid the consequences. Australia needs to be prepared for the challenges that lie ahead—and none of these are more pressing than those involved in trying to protect the health of its people.

This report summarises the discussions and recommendations of a group of early- and mid-career researchers from a broad range of relevant disciplines who came together in July, 2014 to consider climate challenges in relation to health in Australia. The aim of

the Theo Murphy High Flyers Think Tank was to bring novel applications of existing science, social science and technology to the issue and to identify gaps in knowledge that should be addressed. In considering the impact of climate change on human health, the group identified a wide range of potential effects in several broad categories.

The predicted consequences of climate change include increases in extreme weather events, including heatwaves, droughts, storms and floods. They will lead directly to loss of life, and will have a negative effect on the mental wellbeing of communities. The incidences of many diseases are also likely to rise as the climate warms. These will include illnesses born by vectors (for example mosquitoes) as well as water-borne diseases and respiratory ailments.

In addition, rising temperatures will affect food production and water supplies. Disrupted supplies of water and high temperatures will stress crops and promote algal blooms in reservoirs, while rising ocean acidification will affect fisheries. Livelihoods will also suffer. Jobs including farming, fishing and tourism will be particularly badly affected by soaring temperatures, droughts and storms. And finally there is the issue of security. In times of threatened food supply, changing patterns of infectious disease and forced migration from land rendered uninhabitable will trigger tension and unrest. Conflict will be inevitable.

In general, it is likely that the most vulnerable members of the community, in particular the sick, the elderly, the very young and the poor, will suffer a disproportionately from the worst impacts of climate change. This report therefore calls for enhanced research to improve our understanding of the ways that global warming is likely to affect society and to improve methods for identifying those most at risk. This is not just a matter of applying current knowledge to improve health management and risk mitigation strategies, but also involves creating a portfolio of research that will lead to the generation of new knowledge in this field and to the discovery of ways to apply that knowledge so that in future, Australians will be better prepared for and more resilient to health effects when living in a changed climate. This report also addresses the serious issue of how expert advice can best be communicated to governments and their agencies, and to the broader community.

Notes

The authors recognise that the report does not present Aboriginal and Torres Strait Islander peoples' viewpoints on climate change and its potential impacts, and that the references to Aboriginal and Torres Strait Islander peoples may not be in accord with their perspectives on the matters discussed.

The report is presented with acknowledgment of the generous advice and inspiring contribution the late Professor Tony McMichael gave in planning and conducting the Think Tank. Tony was *the* global expert on climate change and human health issues and contributed greatly to increasing public and political awareness of human health as an important consequence of a changing global climate.

Group 1

Temperature and extreme weather events

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Australia's climate is unequivocally changing. Average temperatures are continuing to rise, heatwaves are becoming more frequent and longer lasting while extreme weather events—storms and cyclones, floods and tidal surges—are becoming more common. All can cause substantial damage to housing, infrastructure, communities, health, livelihoods, and ecosystems. Extreme heat is a particularly serious health issue for Australia. It claims more lives than all other natural hazards combined, including tropical cyclones, floods and bushfires. These events are all likely to increase in frequency and intensity as Australia's climate continues to warm. Specific projections are listed in Table 1. They highlight the need for concerted efforts to curb greenhouse gas emissions and actions to address the increased risk of climate-related mortality and morbidity.

Table 1: Projected changes in climate in Australasia

Projected changes	Certainty
Warming projected through 21st century	Virtually certain
Regional sea-level rise to exceed historic rate	Very likely
Fire weather to increase in most of southern Australia	High confidence
More frequent hot extremes, less frequent cold extremes	High confidence
Increasing extreme rainfall and flood risk	Medium confidence
Tropical cyclones projected to increase in intensity	Low confidence

Source: IPCC (2014) WGII AR5

Health effects from extreme weather events

The direct and indirect physical and mental impacts of climate change on health and wellbeing are considerable. Extreme weather events can cause injury and death while infrastructure losses, mental stress and trauma can have long-term effects. Future changes in weather and climate will also have indirect effects through their adverse impacts on agriculture and aquaculture while changes in temperature and rainfall regimes could alter the distribution and transmission of vector-, food- and water-borne diseases. More frequent extreme weather events will also place a greater and growing demand on public health and emergency services.

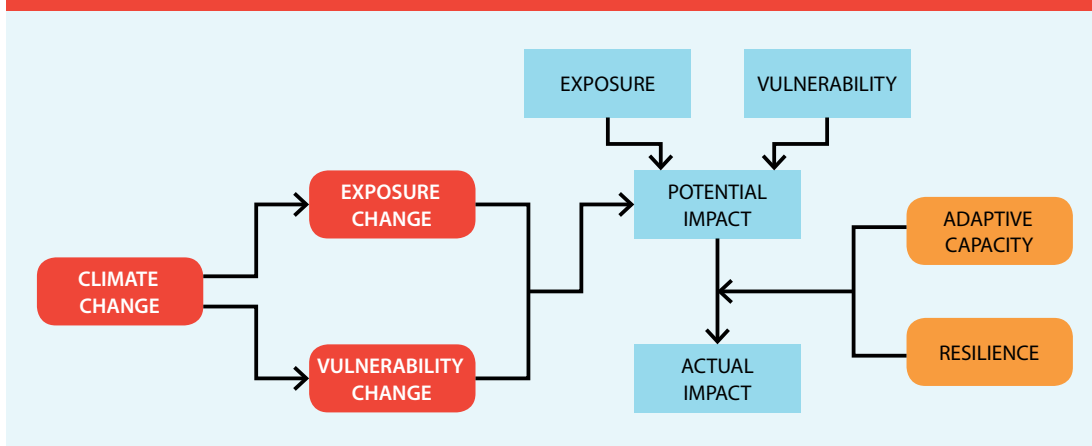
Vulnerability to extreme weather events is a function of exposure to a weather event; the sensitivity of the population to such impacts; and our ability to reduce those impacts through adaptation (Figure 1). The magnitude of future health impacts will depend on the progress of mitigation activities to reduce greenhouse gas emissions as well as adaptation strategies that reduce the exposure and sensitivity of populations.

The dangers posed by extreme heat have been dramatically illustrated in recent years. During the heatwave in Victoria in January–February 2009 there were an estimated 374 excess deaths due to heat and 173 fatalities caused by subsequent bushfires. The Government's 2013 *State of Australian Cities* report predicts that heatwave-related deaths in Australian cities will more than double in the next 40 years. Such events will place significant strain on an already stressed healthcare system with ambulance callouts and emergency department visits rising sharply on very hot days.

Identifying those most at risk

Everyone is at risk during an extreme weather event but some are more vulnerable than others. For example, when temperatures reach core body temperature (around 37°C), people with compromised heat regulation processes due to advanced years,

Figure 1: Factors affecting risk for extreme weather events and climate change



medication or illness are more likely to suffer. The most vulnerable individuals include older people, the very young, those who work outdoors, people with chronic medical conditions, those living with a disability, pregnant and breastfeeding women, the socio-economically disadvantaged and the socially isolated, including those in culturally and linguistically diverse communities. For example, in some communities, social, economic, and linguistic barriers prevent individuals realising there is a need to change their behaviour, such as staying hydrated.

Much more should be done to identify populations and sub-populations at risk from extreme weather events. There is a lack of information on less visible minority groups including the homeless, alcoholics, users of recreational and prescription drugs, people with disabilities or who are immuno-compromised, infants and breastfeeding mothers, people with multiple co-morbidities or undergoing post-surgical recovery, Aboriginal and Torres Strait Islander peoples, and migrants with non-English-speaking backgrounds. There should be careful consideration of future demographic movements, including measures of the likely increase in average age of a population.

A targeted call for suitably funded research would do much to stimulate work in this area and provide a clearer understanding of risk factors, thus increasing the understanding of the distribution of vulnerabilities within societies. By fostering collaboration between researchers and government and non-government agencies, it would also aid in developing prevention strategies for those most at risk during extreme events.

Data sharing and access

A key to fostering collaboration is gaining access to information and sharing it across disciplines. Understanding climate-related threats to health will be greatly enhanced by having data available

in a single national facility that would hold morbidity and mortality statistics as well as weather and climate records, data from projection models, and comprehensive demographic and socio-economic data on the Australian population. Its administration would require close collaboration between state and federal health departments and agencies, emergency services, medical and healthcare professionals, and researchers from a range of disciplines. The benefits to public health, research and adaptive planning would be substantial.

Readily available health data are essential in acquiring a timely understanding of the effects of extreme weather events. At present, extensive delays—sometimes in the order of years—can occur in acquiring mortality data. This hampers emergency responses, resource planning, epidemiological investigations and decision-making. Rapid access to data is also important when preparing for future events. For example, a ‘nowcasting’ surveillance system, as used in the UK during its 2011 heatwave alert, would help reduce the impact of weather-related emergencies. Access to additional data is required for a deeper understanding of the health and social implications of extreme weather. Data on school and workplace absenteeism and coded data from general practitioners would be of special assistance.

Developing an ‘all hazards’ approach

Unprecedented high temperatures, droughts, floods and bushfires have caught authorities and communities off-guard, resulting in substantial fatalities, mental stress and infrastructure losses. Changes have been made to the management of emergencies but there is room for improvement. To compartmentalise responses and allow them to be managed by separate entities is unlikely to be the most effective way to deal with these issues.

Instead, an all-hazards approach is required—one that involves researchers, stakeholders and policymakers working together to improve disaster resilience through coordinated preparation, community action, emergency response and recovery planning.

A national protocol for emergency responses and adaptation to extreme weather events should be developed, one that encapsulates a set of general, all-hazards principles that can then be modified for use by local authorities and relevant service providers. Effective risk communication and timely responses will help build resilience at the individual, community and regional level. The protocol should also consider the possibility of unintended positive and negative health consequences of mitigation strategies; for example, there could be negative repercussions such as the onset of respiratory symptoms caused by pre-bushfire season fuel-reduction burns.

Communicating risk

The disastrous heatwaves and bushfires experienced in 2009 in south-eastern Australia led to changes in emergency management and risk communication. Early warning systems are now in place in several states and bushfire notices are widely disseminated. However people are sometimes reluctant to act, believing the risks are not relevant to them. A better understanding of how warnings are received and interpreted, and why they are often ignored, would help reduce accidents and illnesses caused by extreme weather events. Innovative methods of message dissemination need

to be considered to ensure individuals get access to warnings and advice, particularly the vulnerable, the non-English speaking, the socially isolated and those living in remote locations.

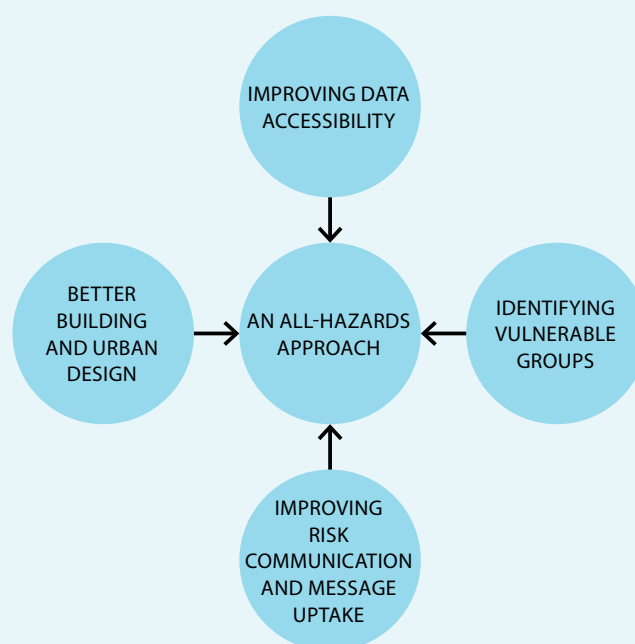
A network of researchers working with the emergency services and government policymakers should be established to formulate alarm messages, build on warning systems already in place, and evaluate the effectiveness of strategies. In particular, this research needs to focus on understanding why warnings are often ignored or disregarded.

Designing for the future

The Australian countryside will be widely affected by climate change. However, the impact of global warming will also affect the workplace and the home. People spend most of their time indoors, but buildings are often poorly designed when it comes to providing protection from extreme weather events while homes are frequently poorly ventilated and insulated. Cooling systems can strain overworked power grids during peak demand, though they are essential in some cases for people with chronic disease in hot weather. Cities also tend to be warmer than surrounding areas due to the urban heat island effect and lack of vegetation, heightening health risks to residents, visitors and workers.

At present, the Australian landscape has a limited capacity for improvements that might alleviate the worst impacts of intense weather events. There is

Figure 2: Recommendations made by Group 1 are interconnected and feed into an all-hazards approach to improve preparation, response and recovery from extreme weather events



therefore a need for research that could lead to better building and landscape designs and to create energy-efficient, 'climate-proof' housing. There is also a need to provide and protect green spaces in residential and commercial zones. Innovative architectural solutions are required to create landscapes that will adequately cope with weather extremes and meet the challenges of future climate change.

Identifying locations at risk would also be useful for city planners, architects and public health practitioners. People who are most vulnerable during heatwaves often live in poor-quality housing in the hottest suburbs. Hazard maps should be created for areas likely to suffer significant health burdens in a warming climate as well as those at risk from floods, bushfires, cyclones and storm surges.

Keeping connected

The recommendations made by Group 1 are linked to one another, as shown in Figure 2, and provide a comprehensive approach to the research required to minimise adverse health effects of future extreme weather events, with a key focus on monitoring, risk communication, preparedness and adaptation.

Group 1 recommendations

1. IMPROVE DATA ACCESSIBILITY

Establish a national facility to collect, archive and provide access to data on the health impacts of extreme weather events and climate.

2. IDENTIFY VULNERABLE GROUPS

Enable research to help identify groups vulnerable to extreme weather events, and document factors that affect the groups' sensitivity in order to develop strategies to reduce those impacts.

3. IMPROVE RISK COMMUNICATION

Improve the quality and effectiveness of early warning systems.

4. DEVELOP BETTER BUILDING AND URBAN DESIGN PRACTICES

Improve guidance and regulation in building and urban design codes to offset adverse health impacts of extreme weather events.

5. INSTIGATE AN ALL-HAZARDS APPROACH

Develop a national protocol to improve preparation, response and recovery from extreme weather events by adopting an all-hazards approach to the problem.

Group 2

Infectious disease ecology and epidemiology

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Infectious diseases place a substantial social and economic burden on Australia. Respiratory tract, food and vector-borne infections all decrease the quality and duration of Australian lives while antibiotic resistance is also becoming a costly problem. This burden is managed within a high-quality healthcare system which is expensive by global standards, although its benefits are considerable. There are a number of threats to the Australian health system, however. Ecological, climatic and demographic changes may alter disease risks. A growing population with high global interconnectedness is at risk from newly emergent diseases for which no treatments currently exist. Investment to ensure the health system remains responsive to these risks is essential because climate projections suggest the incidence of many infectious diseases is likely to increase. Changes to water supply, temperatures, timing of seasonal events, and the intensity and frequency of extreme weather could all increase pathogen replication rates, for example.

The mechanisms by which climate change is likely to influence infectious diseases are poorly understood at present. Some locations may experience decreases while others are likely to experience significant increases. On balance, however, the increases are expected to outweigh the decreases and the challenge in dealing with the problem will grow as global warming becomes more extreme. Measures to limit climate change and counter increased infectious

disease risk should be instituted to maintain our nation's health.

Changes in disease burden anticipated in Australia's future climate are:

- **Vector-borne diseases (e.g. dengue, chikungunya)**

Breeding of vectors like the mosquito will probably alter because of ecosystem change and this will increase Australia's susceptibility to outbreaks of vector-borne diseases. The expansion of disease ranges will put rising numbers at risk, while reductions in incubation times for vector-borne viruses will worsen the problem.

- **Food-borne diseases (e.g. infections with *E. coli*, *Campylobacter*, *Salmonella*)**

Rising temperatures, changes to water supply and extreme weather events are likely to increase the incidence of human food-borne diseases. In addition, more prevalent animal bacterial infection and associated bio-security costs may disrupt food and livestock export markets. Increasing incidence of food-borne diseases could reduce the productive workforce.

- **Water-borne diseases (e.g. *Giardia*, cholera)**

Changes to water availability and higher temperatures will increase the prevalence of water-borne diseases, while replication rates of bacteria will increase as temperatures rise, reaching higher densities and posing greater risk to more people.

- **Respiratory diseases (e.g. influenza, whooping cough)**

As temperatures rise, more people will spend time indoors to avoid the extreme heat, increasing the risk they will pass on respiratory diseases. This problem will be exacerbated by changes in seasons, extension of peak transmission periods, and rises in human population density due to population growth. The displacement of people from other regions as a result of climate change will also increase the rate at which new diseases are brought into Australia and could add to population density.

- **Zoonotic diseases (e.g. Hendra, leptospirosis)**

Climate change will alter the density and movement of both wild animals and livestock in Australia and

affect human–animal contact patterns. This could promote transmission of existing zoonotic disease or increase the risk of novel diseases emerging.

Speeding up detection

A clear problem facing Australia as it prepares to deal with the problem of the rise in infectious illnesses triggered by climate change is its lack of a single centre through which information about communicable diseases can be coordinated and disseminated. Such a disease centre should be considered critical for forecasting and managing future disease risks. It would speed up detection and response times, unify surveillance and management strategies, and allow for more accurate assessments of the health risks that face Australia. The centre would support recommendations for research and communication strategies, and would be the major policy advisory group to the Australian Government and other regional governments. It would coordinate research initiatives; evaluate the capacity of current health systems to cope with projected increased burden; generate more accurate predictive tools for disease risk; and estimate the economic burden of disease. The centre would also play a key role in engaging state and territory health departments, aiding rapid responses to potential threats.

In addition, there is a need to understand the full economic consequences of the projected rise in infectious diseases. This would allow for better disease risk evaluation. Funding is required to generate economic models for the costs and benefits associated with preventative strategies, including the mitigation of climate change. This in turn will place Australia in a better position to combat and limit current and future disease threats. Current analyses make it clear that people of lower socio-economic status are likely to be at greater risk of exposure to new diseases while the elderly are more likely to suffer significant morbidity and mortality. Acquiring data on how infectious diseases will affect our health system—and in particular these two high-risk groups—is needed to reduce future disease burdens by supporting adaptations that are economically sensible.

Ensuring clear communication

The impacts of infectious diseases will vary across Australia and a dedicated research program to develop predictions and models for infectious diseases under climate change is needed. This can best be achieved by promoting an interdisciplinary research agenda to generate early warning systems of disease threats and provide information rapidly and easily for health system policy development and decision-making. This in turn will require good communication between researchers, health workers and government.

Successful implementation of risk reduction and rapid response programs will also depend critically on the support of the public who, in turn, need to understand the risks they face. Information dissemination and educational programs will help build support for long-term policy commitment. The development of a communication strategy using existing science outreach programs and mechanisms would help this. Funding towards educational programs should be a priority.

Group 2 recommendations

6. ESTABLISH AN AUSTRALASIAN COMMUNICABLE DISEASES CENTRE

Create a national, central organisation with regional partnerships to coordinate and disseminate information.

7. UNDERSTAND THE IMPACT OF CLIMATE CHANGE ON HEALTH ECONOMICS

Establish a new research agenda to better understand how the effects of climate change on infectious diseases will affect our economy and our health system capacity.

8. INTEGRATE PREDICTIVE TOOLS FOR INFECTIOUS DISEASES

Establish a new interdisciplinary research agenda to generate better predictive models.

9. DEVELOP COMMUNICATION STRATEGIES

Raise public awareness and support through existing science outreach mechanisms.

Group 3

Food and water supplies

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Australia needs reliable sources of food and water. These are already under stress and human-induced climate change will increase that stress. Water is at risk of contamination with pathogenic micro-organisms (e.g. *E. coli*), heavy metals (e.g. arsenic) and other emerging contaminants (e.g. algal toxins, pharmaceuticals). All can have serious health consequences. The recreational and social uses of water are also important for wellbeing, and contamination will reduce access to water for recreation. In addition, adequate water supplies are needed for food production while leaving sufficient supplies for natural ecosystems.

In Australia, projected climatic changes include higher temperatures and extreme weather events. While frosts (and associated crop damage) may be reduced in some parts of the country, increases in drought and heatwaves will stress crops and are likely to promote pathogen dispersion and algal blooms in water supplies. Meanwhile, rising ocean temperatures and acidity will irreversibly damage key marine ecosystems, including coral reefs, and affect fisheries. Climate change is likely to have a net negative effect on both land-based and water-based food production, threatening food security and livelihoods, both in Australia and overseas. Regional food security issues will also have implications for Australia.

Flood or drought

The effects of climate change will vary within Australia. Drier conditions are expected to prevail in the southern half of the continent, affecting water supply in cities.

Reduced rainfall is also likely to affect Australia's food bowl, the Murray–Darling Basin, which may become more susceptible to pests, crop diseases, and reduced water quality and volume. The combination of prevailing high temperatures, low rainfall and continued fertiliser use will increase levels of algal blooms and associated toxins in reservoirs, rivers and catchment areas.

In addition, northern Australia is likely to experience increases in heavy rainfall events with the risk that flooding will damage infrastructure and crops while also causing the direct loss of life, spread of diseases and pests, and damage to sensitive marine ecosystems—including coral reefs and seagrass beds—that fringe the coastline. Floods are also detrimental to water supplies, soil and crop productivity, and estuarine fisheries.

Paying the price

Adverse impacts on food production will lead to higher prices and may result in reduced access to nutrition, particularly in disadvantaged or remote communities. Food quality and safety will also be affected directly and indirectly by increasing temperatures, potentially changing the nutrient content of food and increasing the cost and complexity of ensuring safety standards.

The actions required to meet this challenge should include climate mitigation strategies. Adaptation policies should also be developed and implemented to minimise health risks. This can be encouraged through demand management—in other words, by changing people's behaviour with regard to food or water. Or it can be achieved through supply strategies—by creating new products or infrastructures to address food and water problems. Examples of demand management include changes in behaviour through education; changes in regulation and planning that affect the use of fertilisers or water; and economic instruments that include new taxes and subsidies to help low-income households. Examples of supply strategies include improved infrastructure for water management, food production and transport; and technological solutions to bring about improved water and land management. New supply strategies could also include new crops better suited to a changed climate; created either through classical breeding techniques or through biotechnology.

Farming in response to climate change

Farmers are the cornerstone of agricultural production in Australia and are major stakeholders in our water resources. They face a need to alter farming practices and adopt new technologies. Governments should help to encourage this process by investing in agricultural extension. Research is also needed and should be directed towards a comprehensive assessment of different types of farming in response to climate change. Particular attention should be given to promoting 'no regret' activities—beneficial activities that are not difficult to implement and that all farmers should be doing regardless of climate change. In addition, more research could usefully be directed to understanding what influences the adaptive capacity of farmers to withstand significant climate variability, and how to increase the resilience of rural communities to environmental change.

The breeding limit

Technology can play an important role in reducing food- and water-related health risks associated with climate change. It could provide ways to improve crop and animal production and develop approaches that are resilient to system shock. A variety of programs should be encouraged in breeding, biotechnology and pest management. Biotechnological approaches should include research into adjusting water or soil microbial communities; new agricultural bio-chemicals; synthetic biology for sensors, pest and pathogen response systems; improving photosynthesis and crop yields; improving aquaculture production; and improving harvest, transport and storage capabilities. At the same time, we need to facilitate management strategies that will encourage people to change their behaviour and reduce their risk of acquiring health-related problems from food and water.

Keeping the water data flowing

One key idea that should be considered is the establishment of a national food and water data coordination body, accompanied by clearer rules on data access and availability. Data should be accessible for researchers, industry and the public to help understand and plan for future food and water health problems arising from climate change. At present, a great deal of health, agricultural and water data are unavailable online. When information is made available, it is often limited geographically and is insufficient for comprehensive analysis. It is also very difficult to get permission to link datasets. This lack of access, linkage and coordination will prevent the

establishment of viable policy and technology strategies for adaptation.

Improved access to food and water data would help identify Australian populations that are most disadvantaged and most vulnerable to food- and water-related health impacts. They can then be monitored and supported where necessary. This activity should incorporate an understanding of how vulnerabilities change over time; how the health of Indigenous populations and other vulnerable populations will be affected by decreasing food supply and increasing food pricing; and how climate change impacts the price and composition of an average food basket in urban, rural and remote communities.

Waste not, want not

In Australia, a very high percentage of food produced is wasted, especially perishables such as fruits and vegetables. This waste can occur prior to shipping, during transport and storage and after purchase. The result is the emission of unnecessary amounts of carbon dioxide, and economic loss. Efficiency should be improved and food waste reduced. Control points and strategies should be identified in the short term, while in the long term technology to support sustainability and food product quality, from farms to consumers, should be developed.

Food, water, health, climate and the environment are all interlinked, with many indirect and direct feedback loops and relationships. There is no single discipline that can provide both an estimate of the costs or problems associated with climate change impact on health and highlight ways to address the complex issues involved. Interdisciplinary engagement is critical.

Group 3 recommendations

10. BOOST PUBLIC INVESTMENT IN AGRICULTURAL EXTENSION

Invest in agricultural extension as a prime way to encourage and facilitate agricultural adaptation to climate change impacts.

11. EXPAND RESEARCH AND DEVELOPMENT

Reverse Australia's downward trend of public investment in agricultural, fisheries and water R&D.

12. ESTABLISH A FOOD AND WATER DATA COMMISSION

Establish a Food and Water Data Commission to coordinate the collation of metadata about food and water. This would fit well within Australia's current data administration facilities, such as the Australian Bureau of Statistics.

13. MONITOR AND HIGHLIGHT VULNERABILITY

Create a national framework for monitoring communities whose food and water supplies are particularly vulnerable. There are many of these communities in remote places and with mainly Aboriginal populations, which will be at the frontline of food- and water-related health risks from climate change.

14. IMPROVE MONITORING OF SUPPLY

Focus research on supply chains in agriculture and food- and water-risk management, and increase the monitoring networks needed to ensure safe and adequate food and water.

15. POOL EXISTING EXPERTISE

Conduct interdisciplinary research and integrate various models—food, water, climate, social, nutrition and economics—to provide greater insights into climate change and health issues. Engage Earth system science in this interdisciplinary activity.

Group 4

Livelihood and disadvantage

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Climate change will fundamentally alter our lives and society. Even moderate changes to our ecosystems will affect livelihoods and the wellbeing of communities. Employment patterns will be changed and businesses will incur losses, either directly through supply chain disruptions or indirectly through increased insurance costs. Social and economic disadvantages will be exacerbated, while even subtle changes in climatic conditions could have indirect implications for livelihoods which depend on infrastructure, services and supply chains—which in turn face risk of disruption.

An example is provided by the tourism industry. Its viability is contingent on the availability of attractions, such as the Great Barrier Reef, to bring visitors. However, increasing ocean acidification that damages coral growth could have dire consequences for that profession. Similarly, a farmer's livelihood is dependent on the availability of water to raise cattle or crops and this livelihood could be badly affected by prolonged, severe droughts in key areas such as the Murray–Darling Basin. Intense storms and strong winds, hotter and longer heatwaves, and more severe floods are already having impacts on many people's livelihoods. They are also disproportionately affecting vulnerable communities which are concentrated in certain cultures, peoples and places in Australia—for example among those living in remote locations. Inadequate housing, infrastructure and health and education services will seriously reduce their capacity to adapt to climate change.

The intersections of climate change, disadvantage and livelihood factors are multiple and interactive, which makes them difficult to address (Figure 3). Indeed, climate change is likely to exacerbate socioeconomic disparities within communities. As the most able adapt and survive, the gap will widen between these more fortunate and those left behind. In research and policy, whole person, whole community, whole-of-life integrative solutions are required—not piecemeal solutions addressing an issue here and a factor there.

Community resilience

Although climate change could seriously threaten our current social fabric, there are various policies that could address vulnerability disparities. One term used to describe such connectedness is 'social capital', which is a combination of community participation and social cohesion that arises when participation is frequent and supportive. Communities with strong social capital are resilient, and their ability to adapt to, and recover from, stresses such as climate change impacts is enhanced. When people come together to solve collective problems—dealing with increased risks of bushfires, for example—social capital can grow. The social support that grows with it provides crucial adaptation resources in time of crisis, and in this way could provide protection to communities faced with the challenges associated with a changing climate.

Adapting in a well-planned way to a world shaped by climate change also could also create new opportunities for livelihoods and reduce disadvantage. Many actions are needed, however: strengthening public health systems, developing low-emission cities and transport systems, and building local infrastructure for community resilience. Improving the local availability of key resources—such as local energy generation, water collection and food production, fostering local social networks, and designing more walkable neighbourhoods—will also help. For example, local production of healthy food could improve resilience to interruptions to food supply chains while also reducing transport emissions, facilitating good nutrition and physical activity and improving food security for low-income families.

Future-proofing the economy

Holistic policy decisions will be required to ensure these sorts of policies are achieved and that risks to health and livelihood due to climate change are minimised. Policy reversals, inconsistent decision making, and implementation delays can all prevent vulnerable businesses and community groups from implementing proactive changes and developing alternative sources of income. Careful consideration of current measures for subsidies and welfare support will be needed to ensure there is strategic strengthening of welfare to 'future-proof' the economy and to avoid welfare cost escalation. In addition, policies designed to respond to climate change should provide incentives for positive livelihood adaptation while supporting disadvantaged groups.

Research is also needed to understand how climate change affects key factors involved in vulnerability, including age, poverty, health, social isolation and financial instability. It is important to know where these vulnerability factors are most heavily concentrated geographically (e.g. in remote communities or poor parts of cities) and to identify whether particular factors change over time or under certain conditions. It is also

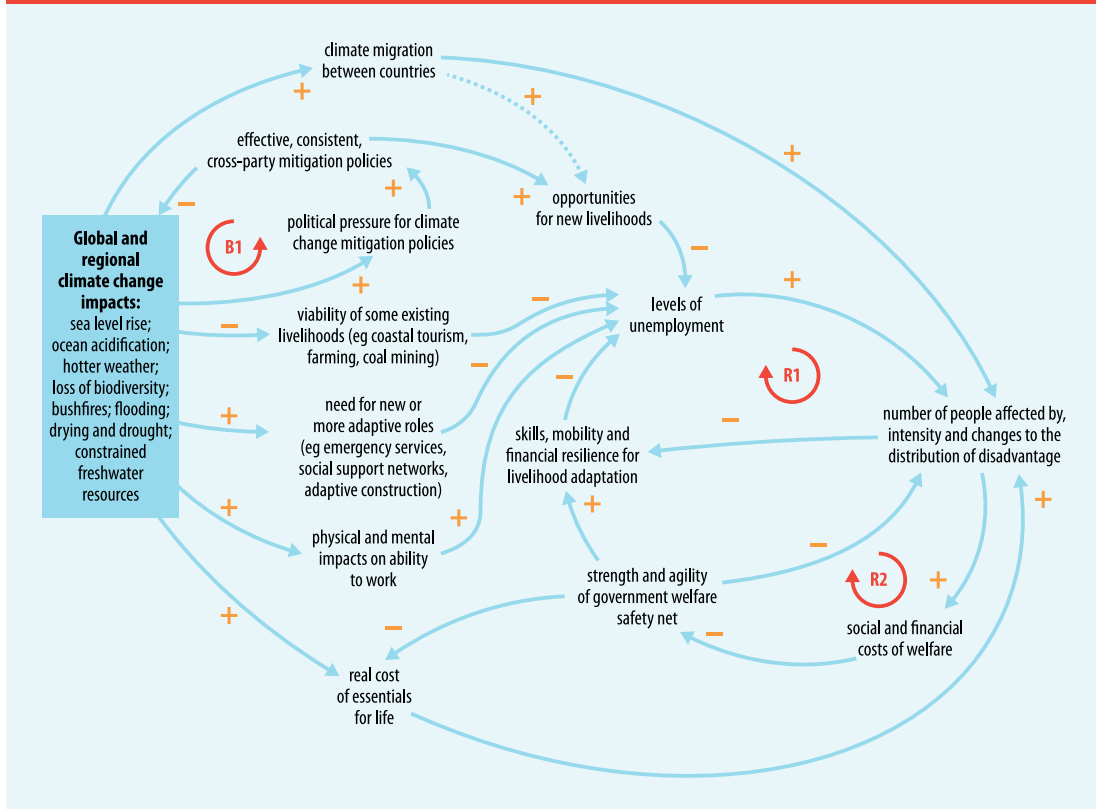
essential to identify 'strong spots'; places where there is vulnerability and also unusual resilience so that it is possible to learn why some areas or groups do well despite disproportionate risk.

Acting now

It is not necessary to wait for government directives to begin helping those most in need. Individuals, communities, local groups, non-profit organisations, schools and universities, health services and many more should get involved in action to better understand and prepare for climate change, and to build social networks to help identify those who are vulnerable to climate change in their local communities and to work out how they can be best supported. This work can start now, for early action could contribute to life-saving outcomes.

Health is shaped powerfully by influences beyond the control of individuals. However, health-promoting, climate-friendly action can be taken in neighbourhoods, workplaces and community settings and, for those with sufficient resources, in their own homes. Climate change will affect livelihoods, a basic building block for health and wellbeing. Many sectors and communities

Figure 3: Causal diagram describing the complex interplay between climate change, livelihoods and socio-economic disadvantage



Arrows with a positive sign (+) indicate a change in the variable at the arrow-tail leads to a change in the variable at the arrow-head in same direction. Arrows with a negative sign (-) indicate a change in the arrow-tail variable leads to an inverse change in the arrow-head variable (opposite direction). R = Reinforcing loop; the result of which is an amplification of the initial pattern of behaviour. B = Balancing loop; the result of which is a dampening of the initial pattern of behaviour.

of Australians are in a position to act now to prepare for the future, benefit from the potential opportunities that will occur and build skills and capacities to cope with new and changing conditions.

Group 4 recommendations

16. SUPPORT LONG-TERM, EVIDENCE-BASED POLICY MEASURES

Develop a consistent strategy to minimise the negative impacts of climate change on health.

17. ESTABLISH A ROBUST, INTERDISCIPLINARY RESEARCH FRAMEWORK

Set up a new research framework to tackle the intersections between disadvantages, livelihoods and wellbeing.

18. ENCOURAGE SELF-DETERMINATION

Communicate that everyone can act now to prepare for the future.

CASE STUDY: DUNALLEY BUSHFIRES

Social media can help mobilise communities during disaster events. During the Dunalley bushfires in Tasmania in 2013, anecdotal evidence showed that social media helped local communities to support each other—quickly. Examples included community-led boat rescues and food and emergency supply deliveries; putting missing individuals back in contact; and communicating messages about fire movements and safe locations. This type of ‘real time’ information sharing saved lives and demonstrated that communities don’t have to wait for government to act and people can come together to protect the most vulnerable. However, this needs to be one strategy amongst others, as a reliance on technology can further disadvantage those without access to these methods, or when systems are down due to weather or disaster events.



Forensic police search for bodies in bushfire-hit Dunalley, south-east Tasmania, on January 7, 2013. Photo: 'Forensic search' by Edith Bevin/ABC. https://flic.kr/abcnews_au/8356043061/. Licensed CC BY-NC 2.0. <https://creativecommons.org/licenses/by-nc/2.0/>

Group 5

Security, social instability and conflict

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Human-induced climate change presents risks to security, on both local and global scales, and is exacerbated by a number of factors that include poverty, conflict, political instability and environmental uncertainty. In the near future, livelihoods could be undermined; food, water and energy supplies threatened; the distribution of infectious disease altered; territories rendered uninhabitable; and forced migration increased. Globally, such consequences will test the ability of nations to support security and could increase violent conflict and tensions within and between countries.

Climate change elevates existing risks through direct health impacts such as heat stress and disaster event injury. Its indirect impacts include under-nutrition associated with reduced food production; mental

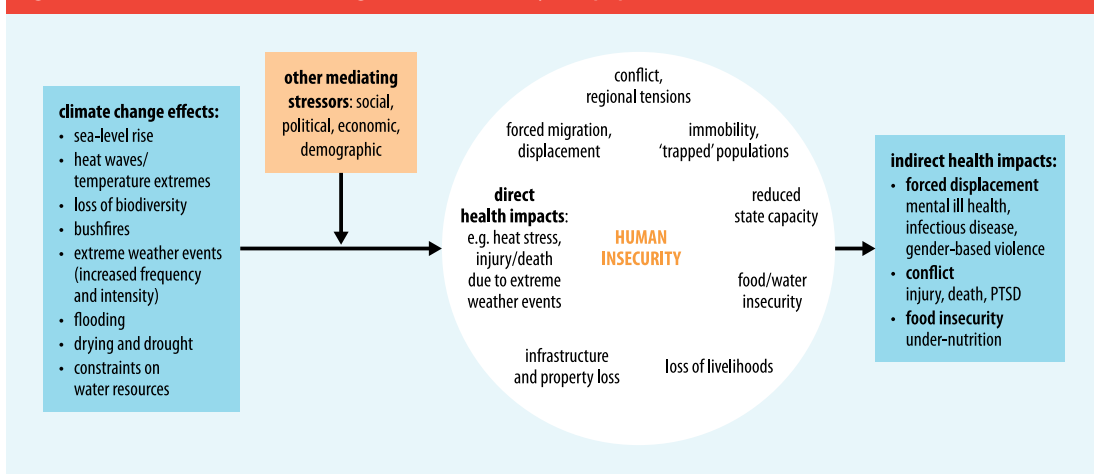
illness associated with forced migration and repeated extreme weather events; changes to the incidence of infectious disease; and adverse outcomes that follow adaptive responses such as planned resettlement (see Figure 4).

Change on a global scale

Australia is 'a land of droughts and flooding rains', and has a long history of managing environmental challenges and of coping with adversity. However the unprecedented scale of the threats posed by climate change will test the nation's capacity to respond. Rural communities and industries will be affected by the availability of resources, particularly water, and this will increase tensions among agricultural, mining and urban dwellers. Domestically, warmer temperatures have been linked to increased interpersonal violence. Risks of climate change to human security and population health will also be highly differentiated by socio-demographic factors, such as age, gender, source of livelihood and economic status.

Internationally, threats to human security and population health will be magnified in low-income countries that are more vulnerable to climate change effects, for example Pacific Island nations. Problems will include: erosion of livelihoods; food insecurity; migration and displacement because of resource

Figure 4: Links between climate change, human insecurity and population health



availability and ecosystems services; sea-level rise; extreme weather events; and increased risk of rivalry and violent conflict within other nations. Australia, which has an important role to play in the Asia–Pacific region, will be not be able to insulate itself from the impact of climate change on its neighbours. Cooperation on adaptation in the region could be mutually advantageous.

Assessing the consequences of climate-related migration in the Asia–Pacific region is therefore an important step. Adverse physical and mental ill-health consequences of migration processes require in-depth research. For example, migration to crowded and under-resourced poor urban areas may elevate exposure to infectious diseases among migrants, and planned resettlement may contribute to poor mental health. Climate change is unlikely to increase conflict within Australia in the immediate future. However, military personnel may be engaged in foreign conflicts, peacekeeping operations and humanitarian missions, with risks to their physical and mental health. Research into the determinants of peace and how institutions can be strengthened to avoid conflict would allow Australia to play a constructive role in the region without endangering its military personnel. At present, the nation's overseas aid is currently among the lowest of developed countries: 0.37% of Gross National Income (GNI) in 2012–2013. Australia's investment in mitigation and adaptation in the Asia–Pacific region is important to reduce the costs and consequences of climate change, to build regional partnerships, and to further support and develop capacity for effective climate responses among countries in our region.

Working together

There should be an improvement in understanding the combined effects of climate change with socio-economic issues such as poverty, migration, conflict, livelihoods, demographic change and human security. This broad agenda should not only describe and measure climate change threats, but also increase understanding of socio-political contexts that can support mitigation and adaptation—both of which are central approaches to population health. Important areas for further research include the investigation of specific vulnerabilities of poor and marginalised people in Australia, such as older people, Aboriginal and Torres Strait Islander peoples, and those experiencing homelessness.

There is also a need to use multi-disciplinary approaches from anthropology, economics, epidemiology, human geography and environmental science to take account of the complex relationships

between climate change, population health, and broader social, cultural, economic, political and demographic processes. Increasing funding for multi-disciplinary research that focuses on environmental change, social systems and population health is equally important.

Developing a clear message

It is critical that awareness of the human consequences of climate change is magnified within public discourse. Human security and population health have a major impact on climate change. Education has a vital role to play in increasing societies' resilience and adaptation to global warming. It is imperative that governmental policies take a proactive role in enhancing education for all sectors of societies. This requires improved communication of scientific evidence, including accessible presentations of research findings and new methods for conveying probabilities and risk; and direct engagement with the private sector, politicians and community groups to transfer knowledge, strengthen decision-making and facilitate change. Climate-focused teacher training and professional development courses should also be enhanced and should include the human security consequences of climate change in the Asia–Pacific region.

Towards a national policy

There are many issues that a national climate policy should consider. These include measures to increase climate change awareness and community-led action; build the capacity of health and community services to respond to climate change and address the vulnerabilities of disadvantaged people; and encourage innovation in the private sector through facilitating social entrepreneurship and co-investing in research and development to produce new products and services that contribute to climate change mitigation and adaptation.

Adaptive strategies might include targeted healthcare services, support services for vulnerable populations, improving community awareness to reduce adverse exposures and outcomes, and developing early warning and emergency response plans. An evidence base for the effectiveness of strategies requires consideration of socio-economic and human security dimensions, including wealth and its distribution, access to information and resources, livelihoods, ageing, gender, socio-cultural values, migration patterns and conflict resolution processes. Further consideration also needs to be given to whether current adaptive initiatives constrain or reduce future adaptive responses.

Group 5 recommendations

19. ESTABLISH A MULTI-DISCIPLINARY RESEARCH AGENDA TO UNDERSTAND THE FULL RISKS TO HUMAN SECURITY

Develop a better understanding of the combined, emergent effects of climate change on human security.

20. SET UP NEW COMMUNICATION STRATEGIES

Develop innovative education and communication mechanisms to provide an evidence base for policy- and decision-making, and to raise public awareness of the impacts of climate change.

21. ESTABLISH A CREDIBLE NATIONAL CLIMATE POLICY

Establish a climate policy for Australia that focuses on emission reduction targets.

22. IDENTIFY AND UNDERSTAND EFFECTIVE ADAPTIVE PRACTICES

Identify and collate practices that reduce human insecurity and support population health both nationally and regionally to apply them in other contexts.

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