sustainable settlement

CLIMATE CHANGE

The Climate System & Climate Change

Australian Institute of Landscape Architects

National Policy Statement

Over the past few years, climate change has emerged as the major social, economic and environmental challenge facing contemporary society.

The reports of the Intergovernmental Panel on Climate Change (IPCC) provide the scientific basis to our understanding of climate change.

In particular, the IPCC Fourth Assessment Report (IPCC 2007) stresses the need for a fundamental transition in the structure and functioning of human settlements, including built environments, to simultaneously mitigate climate change and adapt to the effects of climate change (Pizarro 2009a).

The term 'climate change' refers to a statistically significant change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2001).

The term 'climate change' can apply to either a change in the mean (average) state of the climate or a change in the climatic variability. The change is one that persists for an extended period, typically decades or longer (IPCC 2001).

The climate system is highly complex and involves multiple components, including the atmosphere, the hydrosphere, the land surface and the biosphere, as well as the interactions between them (IPCC 2001).

The climate system evolves over time and climate change may occur under the influence of natural internal processes or because of external forcings (such as volcanic eruptions and solar variations), or because of persistent human-induced forcings, such as anthropogenic changes in the composition of the atmosphere or in land use.

Greenhouse gases

Of particular interest are greenhouse gases (GHGs), such as carbon dioxide (CO_2), methane (CH_4), water (H_2O), nitrous oxide (N_2O) and ozone (O_3), since these trap heat near the earth and can contribute to warming of the climate system. While GHGs can be either natural or anthropogenic in origin, the rapid growth associated with the Industrial Revolution, from about 1750 onwards, saw the beginning of a strong increase in the use of fossil fuels and emission of, in particular, fossil CO_2. Fossil fuel use, land use changes and agriculture all contribute to GHG emissions.

This paper incorporates text by Dr Jane Tarran prepared in 2010 for AILA's Climate Change Adaptation Skills for Professionals Program.

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Climate change science to 2007

Scientific understanding of climate change up to 2005-2006 is summarised in the IPCC's Fourth Assessment Report (IPCC 2007; AR4). The primary conclusions from the IPCC Working Group 1 (IPCC 2007; Steffen 2009) on core aspects of climate change science are:

- Warming of the climate system is unequivocal, given observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea- level
- Numerous long term changes in climate have been observed at continental, regional and ocean basin scales
- The warmth of the last half century is unusual, the last time this occurred being about 125,000 years ago, in association with a 4-6 m rise in sea-level
- Most of the observed increase in global average temperatures since the mid-20th century is very likely (>90% probability) the result of the observed increase in anthropogenic GHG concentrations
- Continued GHG emissions at or above current rates would cause further warming and induce even larger changes in climate in the 21st century than those observed in the 20th century

Climate change science update, 2007-2009

Climate science continues to be the focus of much research and new developments in key areas since the IPCC's Fourth Assessment Report (IPCC 2007) are summarised by Steffen (2009), in his report "Climate Change 2009: Faster Change and More Serious Risks", with a particular emphasis on issues of importance to Australia. These new findings are:

Climate change appears to be occurring faster than we previously thought likely

Whilst some uncertainties still remain as to rates and magnitudes of processes, the majority still point towards more rapid and severe climate change

Given the above, more attention is now being directed towards the need to adapt, and the possible limits to adaptation; for Australia, critical issues are sea-level rise, severe droughts and drying trends, increases in extreme climatic events like heatwaves, floods and bushfires, and more acidic and warmer oceans affecting marine resources and ecosystems, including the Great Barrier Reef

Climate change is complex, with smooth changes occurring in mean values of some attributes, but abrupt changes occurring in others; nevertheless, effective societal adaptation strategies can be developed by enhancing resilience or building the capacity to cope with new climate conditions; there is an urgent need to reduce GHG emissions to avoid the risk of crossing dangerous thresholds in the climate system

Long-term feedbacks may be starting to develop now (e.g. in polar ice sheets and carbon sinks) and, once thresholds are passed, these processes cannot be stopped or reversed, the outcome of which is more severe and ultimately irreversible climate change

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CLIMATE CHANGE PROJECTIONS

Global projections, risks and impacts

Although the consequences of climate change cannot be predicted with complete certainty, we have enough information to understand the risks. Climate change presents very real global risks and demands an urgent global response (Stern 2006). Reviewing the scientific and economic evidence, the Stern Review (Stern 2006) concluded that the benefits of strong early action considerably outweigh the costs. Similarly, Garnaut (2008), examining the impacts of climate change on the Australian economy and the costs of response measures, concluded that Australians did indeed face risks of damaging climate change and that the risk could be substantially reduced by "strong, effective and early action" (Garnaut 2008 p. xvii).

Using the past 1000 years of temperature data (paleo-record reconstructions and more recently raw data), a baseline envelope of natural variability is established (shaded area at base of Figure 3). The temperature in the Northern Hemisphere in 2100 is projected to be 1 to 6oC warmer than it was in 1990, a range well above the envelope of natural variability. These projections increase the risks and impacts associated with climate change significantly beyond the risks and impacts experienced by society over the previous 1000 years.

Climate change in Australia during 1960-2009

A review of climate-related data over the period 1960 to 2009 (CSIRO & Bureau of Meteorology 2010) summarised climate changes that occurred in Australia during this period as follows:

- All of Australia has experienced warming; while the mean temperature has increased by about 0.7oC since 1960, some areas have experienced warming of 1.5-2oC
- The number of days with record hot temperatures has increased each decade, with 2000-2009 being Australia's warmest decade on record
- Rainfall has decreased across much of southern and eastern Australia (where major population centres are), while it has increased in many parts of northern and central Australia
- The rate of average global sea-level rise increased during the 20th century and was about 3.0mm per year during 1993-2009; during this period, sea-level rise in Australia was 1.5-3mm per year in the south and east and 7-10mm per year in the north and west
- Sea surface temperatures around Australia have increased by about 0.4oC in the past 50 years
- Atmospheric CO2 (measured at Cape Grim, Tasmania) has increased from about 330 ppm to 385 ppm during the period 1975-2010; this concentration is much higher than the natural range of 170-300 ppm that has existed in the atmosphere for at least the last 800,000 years

Climate change projections for Australia

The main projections for Australia in the coming decades include the following (CSIRO & Bureau of Meteorology 2010):

- Australia will be hotter, with average temperatures projected to rise by 0.6 to 1.5oC by 2030 and changes being felt through an increase in the number of hot days; temperature rises of 2.2 to 5.0oC by 2070 are projected if global GHG emissions continue at current levels
- Much of Australia will be drier, particularly in the southern and eastern areas, as well as in south-west Western Australia, with decreases in rainfall varying seasonally in different areas
- An increase in the number of dry days is expected across the country, but it is likely that there will be an increase in intense rainfall events in many areas

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Risks from a rapidly changing climate in Australia

Risks associated with observed and projected rates of climate change in Australia include the following (Steffen 2009; Department of Climate Change 2009b):

- A sea-level rise of 0.5 to 1.0m by 2100 compared to 1990 values is projected to occur, but a larger rise (e.g. to 1.5m) cannot be ruled out
- The many risks associated with sea-level rise include increased vulnerability to inundation of low-lying islands, increased erosion of sandy coastlines and consequently a retreat landwards, large increases in the frequency of extreme sea-level events associated with high tides and storm surges, with one-in-a-hundred-year events occurring 2-3 times per year
- Drying trends in much of Australia will affect water availability in both urban and rural Australia, with particular risks for the most populous and agriculturally productive parts of the
- An increase in the frequency of long periods of diminished rainfall and increased evaporation is projected to reduce the amount and reliability of water supplies, making water resource management increasingly difficult and impacting on availability of urban water, water for agriculture, environmental flows and hydroelectric energy production
- Increasing acidification of the ocean, as it absorbs CO2 (and forms carbonic acid), inhibits shell formation in many marine organisms, including corals, oysters, sea urchins, mussels, crustaceans and some plankton; corals, such as those of the Great Barrier Reef, are particularly vulnerable to both increased ocean acidification and increased sea surface temperature and are projected to be overwhelmed in the second half of this century (based on current trajectories)
- An increase in the frequency and severity of extreme events, such as storms, floods, fires and droughts, is projected to occur
- Larger and more intense fires are likely; there have been two megafires in the last decade in south-east Australia (Canberra in 2003 and Victoria in 2009) and, while the link between climate change and bushfires is complex, and bushfires and their impacts are influenced by many factors, fuel loads are more susceptible to burning and extreme fire weather days are more likely under a warming climate
- Other extreme events that could be affected by climate change, but require further research, are the frequency and intensity of tropical cyclones, heatwaves, thunderstorms, heavy rain and hail; several extreme heatwaves have occurred over the past decade, such as in south-east Australia in February 2004 and in Melbourne, Canberra and Adelaide during the summer of 2008-2009; heat extremes adversely affect people's health, infrastructure and food production

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MITIGATION AND ADAPTATION

Responses to climate change

The two fundamental response options open to societies are mitigation of climate change and adaptation to climate change (Füssel 2007):

- Mitigation refers to limiting global climate change by reducing the emissions of greenhouse gases (GHGs), such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), or enhancing their sinks (which are processes, activities or mechanisms that remove GHGs)
- Adaptation responses refer to adjustments (in natural or human systems) made in response to actual or expected climatic changes or their effects, which moderate harm or exploit beneficial opportunities (Department of Climate Change 2009a)

While mitigation measures aim to avoid the adverse impacts of climate change in the long term, adaptation measures are designed to reduce the unavoidable impacts of climate change in the short and medium terms (Davoudi et al. 2009b). Adaptation responses are the main means to minimise losses (and maximise gains) associated with climate change. They should provide a net economic, social or environmental benefit no matter what level of climate change occurs. Mitigation is important in reducing the likelihood of exceeding the adaptive capacity of natural systems and human societies.

Initial focus on mitigation

For historical reasons, mitigation and adaptation have been treated separately in both scientific and policy discussions, even though they are closely linked as an integral part of sustainable development and both aim to reduce the undesirable consequences of climate change (Füssel 2007). Since climate change was originally perceived as an environmental problem, similar to ozone depletion, mitigation was given priority, since it was believed that the problem could be addressed by setting targets and timetables for GHG emission reductions (Davoudi et al. 2009b).

Mitigation has also received much greater attention than adaptation, for several other reasons (Füssel 2007):

- Mitigation can reduce impacts on all climate-sensitive systems by targeting the source of the climate change problems, whereas the potential for adaptation is limited for many systems
- Mitigation provides certain benefits because it reduces the cause of the problem, whereas the effectiveness of adaptation is not as certain and depends on the accuracy of climate change projections
- Mitigation applies the polluter-pays principle, whereas adaptation needs are likely to be greatest in developing countries whose historical contribution to climate change has been small
- Mitigation outcomes are easy to monitor via greenhouse gas emissions, but adaptation outcomes, like future impacts avoided, are harder to measure

Renewed interest in adaptation

Subsequently, a renewed interest in adaptation developed, for several reasons (Füssel 2007):

- It was realised that climate change was already happening, that impacts were occurring on many natural and social systems, and that these impacts needed to be addressed
- It was further realised that climate change would continue for the foreseeable future because of the accumulation of GHGs already in the atmosphere and the inertia of the climate system; adaptation to the impacts that are already “locked in” was seen as essential (National Climate Change Adaptation Research Facility (NCCARF) undated), even if there were substantial efforts to reduce emissions (via mitigation measures)
- Adaptation measures have a shorter lead time than mitigation measures, with the effect of emissions reductions (via mitigation) taking at least several decades to become fully apparent
- Adaptation measures can be implemented on a local or regional scale and their efficacy is less dependent on the actions of others, as is the case for mitigation measures (since mitigation is only effective if undertaken globally)
- Adaptation measures have important additional benefits, such as reducing any current climate-sensitive risks

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Synergies, conflicts and trade-offs: the mitigation/adaptation conundrum

Recent discussions now focus more on mitigation and adaptation as potentially complementary measures and the need to pursue both in tandem as part of an integrated framework for addressing climate change (Davoudi et al. 2009b).

However, while there may be synergies between mitigation and adaptation measures, there are also potential conflicts, and thus situations where trade-offs will be made (Hamin & Gurran 2009).

What is now emerging is a conundrum between mitigation and adaptation in planning for climate change and human settlements (Howard 2009; Pizarro 2009a). It has been claimed that mitigation itself is the "most fundamental and urgent form of climate change adaptation" (Howard 2009) but that it is possible, with the recent focus on a range of adaptation measures, that commitments to mitigation might be weakened by the apparent attractiveness of adaptation.

Potential conflicts between mitigation and adaptation include:

- concentrating development in higher densities (mitigation measures to reduce car travel) and the loss of urban forests and other urban green areas (adaptation measures to cool buildings and footpaths, and hence reduce heat island effects)
- concentrating development in higher densities (mitigation measures) and the loss of open space for water inundation (adaptation measure to reduce storm runoff and flood risk)

Potential synergies between mitigation and adaptation include:

- increasing urban forests and other green infrastructure as both a mitigation measure to sequester carbon and reduce fossil fuel emissions (by reducing airconditioning needs) and an adaptation measure to cope with higher temperatures (by cooling buildings, footpaths and reducing heat island effects) and storm-associated flood risks (by intercepting and temporarily storing increased runoff)

It is likely that the form of human settlements which will respond best to the needs of both adaptation and mitigation will be one where available resources achieve multiple goals (Hamin & Gurran 2009) and where sustainable development provides the framework to identify problems, involve the public and to devise strategies to deal with mitigation of and adaptation to climate change (Pizarro 2009a&b).

For example, it is suggested that moderate density, with fingers of green infrastructure running through the city, may be the most effective form to achieve a trade-off between mitigation and adaptation (Hamin & Gurran 2009).

RESPONSES TO CLIMATE CHANGE IN AUSTRALIA

Recent initiatives at national, regional and local levels

Australia's climate change strategy is built upon three pillars — making efforts to reduce Australia's emissions (mitigation), helping to shape a global solution and adapting to the impacts of unavoidable climate change (Department of Climate Change 2010 p.16).

The potential effect of climate change on society and natural assets depends on exposure to changes in the climate system and sensitivity to those exposures (Garnaut 2008).

Australia is one of the hottest and driest continents on earth and has one of the most naturally variable climates in the world. Our geography, coastal population concentrations and unique biodiversity further increase the likely impacts of climate change in Australia. Since both exposure and sensitivity are high for Australia, the potential impacts of climate change are similarly high.

Vulnerability to climate change, however, is influenced by the capacity to adapt to climate changes and, as a nation, Australia has a high level of capacity to plan for and respond to the potential impacts of climate change. The ultimate extent of impacts will also depend on the success and timing of global greenhouse gas mitigation.

Over the last five or so years, there has been a substantial increase in activities relating to Australia's responses to climate change, particularly by the Australian Government in developing strategies and frameworks, as described in "Australia's Fifth National Communication on Climate Change: A Report under the United Nations Framework Convention on Climate Change" (Department of Climate Change 2010).

The most important past and current actions in the area of adaptation to climate change include the following (Department of Climate Change 2010):

- The National Climate Change Adaptation Framework endorsed in 2007 by the Council of Australian Governments (COAG) and an Australian Government Position Paper on Adapting to Climate Change in Australia published in 2010 (Australian Government 2010)
- Establishment of the CSIRO Climate Adaptation National Research Flagship and the Climate Change Adaptation Program, including the National Climate Change Adaptation Research Facility (NCCARF), designed to address problems relating to adaptation and bridge the gap between science and policy, with the support of eight sectoral Adaptation Research Networks
- The Australian Climate Change Science Program to provide the foundation for understanding the expected impacts of climate change in Australia and bringing together the Australian Government, CSIRO, the Bureau of Meteorology (BoM) and leading universities
- National-level vulnerability assessments in key vulnerable sectors, including coastal areas, biodiversity, national infrastructure and indigenous communities, with reports publicly available on www.climatechange.gov.au/publications/index.html
- Regional vulnerability assessments to assist decision makers to frame adaptation responses to the likely impacts of climate change on regional and local issues
- Sectoral adaptation measures in biodiversity and natural ecosystems, coastal zones, settlements and infrastructure, emergency management, agriculture, fisheries and forestry, tourism, human health, water resources, local and regional planning, and tools and support for adaptation planning

Activities have also increased at regional (State and Territory) and local (Local Government) levels, since responsibility for dealing with climate change is shared amongst all three levels of government and regional and local levels will have a major role in direct adaptation actions. These measures include regionally and locally relevant research into impacts and adaptation measures, as well as new modelling and mapping, via government and academic collaborations.

Education about and for climate change adaptation and mitigation

To build adaptive capacity to deal with climate change impacts, there is a need for rapid adoption of education about and for climate change adaptation, including ongoing professional development initiatives (Lyth et al. 2007).

Education related to climate change adaptation should be addressed in an integrated way with education about and for climate change mitigation. Given both the synergies and the potential conflicts between the two types of responses, education programs must consider both.

Some adaptation responses are already being implemented within the context of sustainability. In relation to climate change adaptation and the planning profession, Steele and Gleeson (2009) have suggested that there is a need to move to a further stage of planning in climate change. Whereas planning for climate change regards climate change as a real, but still distant, agenda (and just one of a suite of planning interests), with some action taken now but more later if required, planning in climate change regards climate change as a lived agenda, with immediate action required that must be sustained over the long term. The observations on climate changes that occurred in Australia during the period 1960-2009 (CSIRO and BoM 2010) reinforce the fact that we have indeed moved into an era of planning in climate change.

Seeking integrated design solutions for national Sustainable Settlement

The Australian Institute of Landscape Architects strongly urge the Australia's Federal and State Governments to provide an integrated vision for a sustainable future and to implement a national Sustainable Settlement policy that will guide a consistency of approach in all settlement development across the nation.