LANDSCAPE LOGIC
LINKING LAND AND WATER MANAGEMENT TO RESOURCE CONDITION TARGETS

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Rural landholders adapting to climate change

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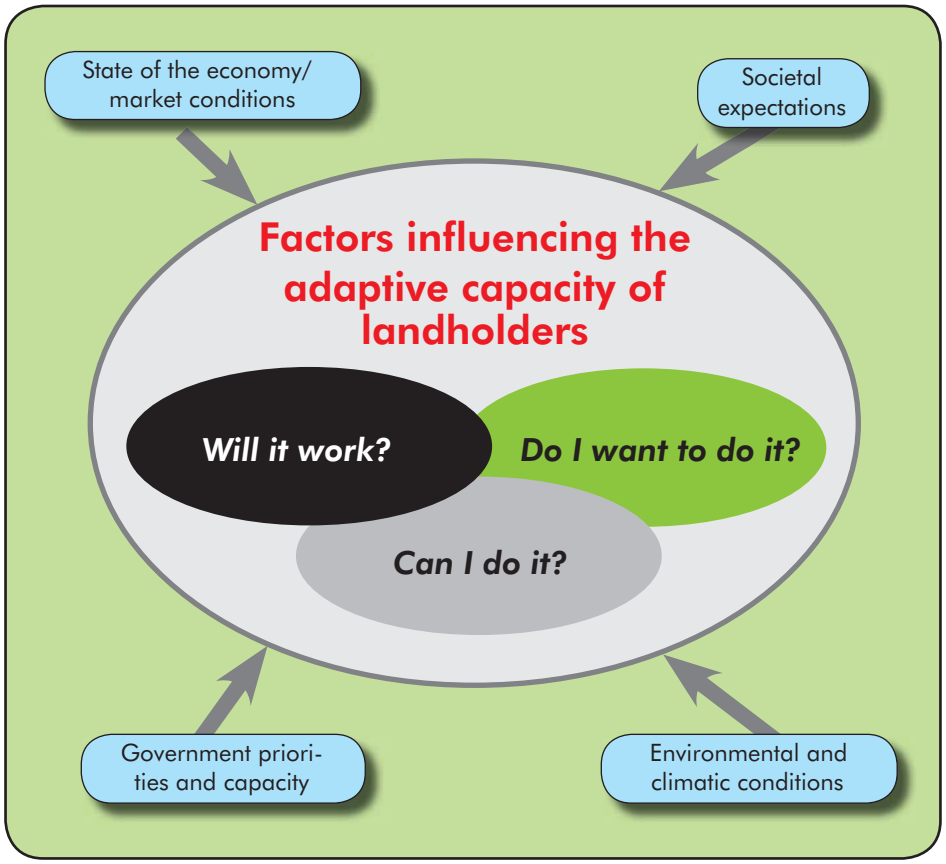

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LANDSCAPE LOGIC is a research hub under the Commonwealth Environmental Research Facilities scheme, managed by the Department of Environment, Water Heritage and the Arts. It is a partnership between:

- **six regional organisations** – the North Central, North East & Goulburn–Broken Catchment Management Authorities in Victoria and the North, South and Cradle Coast Natural Resource Management organisations in Tasmania;
- **five research institutions** – University of Tasmania, Australian National University, RMIT University, Charles Sturt University and CSIRO; and
- **state land management agencies in Tasmania and Victoria** – the Tasmanian Department of Primary Industries & Water, Forestry Tasmania and the Victorian Department of Sustainability & Environment.

The purpose of Landscape Logic is to work in partnership with regional natural resource managers to develop decision-making approaches that improve the effectiveness of environmental management.

Landscape Logic aims to:

1. Develop better ways to organise existing knowledge and assumptions about links between land management actions and environmental outcomes.
2. Improve our understanding of the links between land management actions and environmental outcomes through historical studies of the effects of private and public investment on water quality and native vegetation condition.

Rural landholders adapting to climate change: Social research perspectives

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Summary

This report presents the theoretical framework underpinning research by the authors examining rural landholder adaptation to climate change. Research funds were provided by *Landscape Logic,* one of the Australian Government's Commonwealth Environmental Research Facilities (CERF) hubs and the Natural Heritage Trust through the North Central Catchment Management Authority (NCCMA).

In the body of the report we draw on a substantial body of literature to:

1. ***summarise recent social research*** examining climate change dialogues, wider public and rural landholder knowledge, attitudes and beliefs about climate change;
2. ***identify useful frameworks*** for describing and understanding rural landholder adaptation to climate change; and
3. ***suggest some principles*** to guide effective communication and engagement with rural landholders about climate change.

Climate and risk perception

Climate change can be (and has been) described as a classic risk issue. Human beings invented the notion of 'risk' to help understand and cope with the dangers, opportunities and uncertainties of life. Contemporary definitions typically position 'risk' as something more negative than positive: the frequency or probability of occurrence of potentially harmful events plus the magnitude of the consequences.

Since 'risk' is socially constructed, it is possible to identify patterns of similarity and difference in the way people perceive and respond to risks generally, and to the risks of climate change in particular. Risk research based in the social sciences has provided valuable insights about patterns of individual risk decision-making; the different kinds of knowledge about and responses to risks among societal groups; and how institutional structures and forms of decision-making position risk.

Prevailing attitudes to climate change

Recent Australian and overseas social research has identified a relatively high level of public awareness of climate change and its negative impacts. However, there is also considerable misunderstanding about aspects of the science underlying climate change and some people are confused about the exact nature, causes, and consequences of climate change. Many people don't see climate change as a personal threat. While there is broad, public support for a range of mitigation policies, that support tends to be contingent upon perceived convenience, personal benefits, and trust in government and science providers.

The particular characteristics of climate change, people's mental processes, and their social experiences interact to influence their views of and/or positions on climate change. Factors that reduce the significance of climate change in people's minds include:

- ***the slow and abstract nature*** of climate change risks (e.g. a 'creeping environmental problem' makes it difficult for a wide range of people to understand);
- ***lack of personal experience*** of climate change impacts means that they are perceived as distant in space and time; and
- ***refusal to accept harm*** as people seek to maintain the 'status quo' and allow vivid images of good outcomes to suppress consideration of the probability of negative impacts.

Consequently, many people do not see climate change as a 'problem' that necessarily warrants (personal) action in the short-term.

People's views and actions are also a function of their social identities and experiences. Our interactions with other individuals, groups, organisations and modern institutions (e.g. the media and governments) have the potential to change our thoughts and actions. We are also exposed to and/or

are affiliated with different 'interpretive communities', which can be distinguished in a number of ways (e.g. expert/scientific communities versus the lay public) and whose views about the threat of climate change and the need for action run along a spectrum – with low risk perceptions at one end, high risk perceptions at the other, and a range of positions in between relating to the salience of climate change and the need for action.

People's responses to climate change are also informed by institutions such as the media. The media has tended to oversimplify climate change, polarise the climate change debate and exaggerate the degree of disagreement and highlight overwhelming or frightening images – which some believe has reinforced public uncertainty, scepticism, anxiety, denial and/or confusion. However, recently the media, political interest and some experiential forces have converged to play a key role in *increasing* the Australian public's general awareness and concern about climate change.

Landholder responses to climate change

In contrast to recent Australian opinion polls suggesting high levels of awareness and concern about climate change amongst the wider public, several case studies in agriculturally-dependent communities in NSW and Victoria have identified highly variable levels of awareness and understanding of climate change. A substantial proportion of these research participants were unable to clearly distinguish between climate risks more generally (e.g. drought, variable climate) and 'climate change' in particular. Participants frequently saw drought as part of the 'natural' climate cycle, which would (hopefully) break soon and there would be a return to more normal (wetter) conditions.

While climate risk management is not always readily identifiable from the myriad risks that farmers and other landholders are 'managing' (or adapting to) at any given moment, researchers have identified a range of actions being implemented by landholders overseas and in Australia, including:

- ***land and resource management practices*** such as changing production strategies and techniques (reduced stocking rates, adjusting planting dates, changing crop varieties or livestock breeds, fodder storage);
- ***financial management strategies*** such as the use of insurance, diversifying off-farm investments, industry exit;
- ***climate forecasting and planning*** including the use of seasonal climate forecasting; and
- ***capacity-building***, and participating in networks.

Adaptive capacity

There will be differential capacities of rural regions, industry sectors, communities and individuals to adapt to climate change. Adaptive capacity is determined by a range of complex, interactive factors and conditions, operating at different scales, which function to drive/enable and/or constrain the ability to make adjustments. From our review of the literature we propose a four-pronged framework used in other natural resource management settings as a useful way of understanding this complex array of interactive factors influencing the adaptive capacity of individuals [Figure 1, Appendix 1]. This framework includes the following sets of factors:

- ***personal characteristics*** that underpin motivation, intention and decision-making;
- ***access to resources*** needed for any given adaptation;
- ***adaptive practices*** and technologies, including their feasibility, delivery and benefits; and
- the ***broader operating environment.***

Generally, there is more understanding of the personal characteristics which drive and/or constrain desirable responses to climate change. Greater effort is needed to understand how the elements of the framework interact.

Principles for effective communication and engagement

One-way models of communication that construe a single, naïve public that must be persuaded to change their values and goals are unlikely to be helpful. This review suggests we need to re-think how Western society communicates about risk generally and seeks to engage people on environmental risks such as climate change. It is time to consider more systematically whose behaviour that different actors are seeking to change and towards what ends.

Lately climate change is seen as 'core business' for regional NRM practitioners. A key tool to support resource managers is recognising the social dynamics that underpin their efforts to adaptively manage climate change in their regions. Regional NRM managers will be seeking dialogues primarily with (rural, regional, agriculturally-dependent) communities and landholders, those conversations need to be targeted, interactive, and inclusive. There will also need to be a shared responsibility among decision-makers at a range of jurisdictions to identify ways to increase the attractiveness of climate change adaptation (and mitigation) practices. The following principles should guide the development of effective communication and engagement strategies.

Audiences

- Recognise the diversity of the climate change audience and match information provision to audience needs and interests.
- Clarify the goals of engagement with different audiences (mass communication techniques to spread messages widely; direct, personalised approaches when seeking stakeholder or community involvement).
- Recognise and address the needs of the more vulnerable sectors of communities.
- One-on-one, interactive extension services for land management drawing on experts seen as credible and trustworthy by their respective audiences.

Approaches/messages

- Provide institutions and infrastructure that interrupt habitual, undesired behaviours and encourage consideration/use of alternatives (e.g. 'breakfast fora' for farmers to engage climate scientists, fuel discounts for minimum-tillage croppers, subsidised rainwater tanks and solar panels).
- Use approaches that provide maximum choice and flexibility and combine positive reinforcement with some external pressure (e.g. regulatory, fiscal frameworks).
- Use messages that connect climate change issues with concerns people feel persistent and personal responsibility for.
- Use messages that acknowledge uncertainty and that climate change effects are not easy to control, but start with what is most likely to ensure audiences hear and retain the intended 'take home' message.
- Use images that trigger appropriate affective and intellectual responses – seek to enhance the salience of climate change by localising and personalising it. Avoid scare-mongering and provide information about practical ways for people to make a difference.
- Work within time frames that are more easily appreciated by people (e.g. alternative visions and scenarios 10–20 years into the future rather than 30–50 years). Promote the positive consequences of action (e.g. ''response-ability'').

Future research needs

This review has provided important insights that have enabled us to build a framework that can guide future research on encouraging adaptation to climate change and disabling some of the factors which might impede climate change adaptations. We recommend that such research should:

- ***describe how people think*** about and respond to climate change;
- ***identify and rate the different kind of risks*** landholders are responding to in relation to climate-related risks such as 'climate change';
- identify ***landholders' views about their own ability to adapt*** and what resources/support they feel they need;
- ***compare landholders' adaptations to climate change with formal 'best practice'*** recommendations, assess the implications of landholders' practices for improved resource condition; and
- measure ***levels of support for and trust in NRM policies,*** programs, practitioners and information.

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1. Introduction

This report presents the theoretical framework underpinning research by the authors examining rural landholder adaptation to climate change. Our research involves two district-scale case studies in northern Victoria. Research funds were provided by Landscape Logic, one of the Australian Government's Commonwealth Environmental Research Facilities (CERF) hubs and the Natural Heritage Trust through the North Central Catchment Management Authority (NC CMA). The first case study was in the Kamarooka and Muckelford districts near Bendigo (Thwaites *et al.* 2008). A second case study will be undertaken near Wodonga in 2009.

Landscape Logic aims to test the assumed links between recommended land management practices and improved environmental outcomes for native vegetation in Victoria and water quality in Tasmania. The social research team in Landscape Logic is exploring the social acceptability of recommended practices and landholder understanding of the assumed links between practices and resource condition. As part of this research, we wanted to explore landholder perceptions/beliefs about climate change and the extent that climate change was influencing their land management. With other scientists in Landscape Logic, we could then explore the environmental implications of any adaptations identified.

Climate change is a serious global issue and is expected to increase the variability of Australia's highly dynamic climate systems. South-east Australia is expected to experience increased annual average temperatures, decreased frosts, and lower rainfall. A shift to a warmer and drier climate will have significant negative social and economic implications for farming (e.g. lower yields, increased production costs) and the wellbeing of rural landholders and regional communities (water availability, comfort, employment, recreation).

There is an active public dialogue about 'climate change'. These conversations reflect variable use and understanding of terminology, including 'climate variability', 'climate change', 'global warming', and 'drought'. While there is growing confidence about certain aspects of climate change, uncertainties persist. There is still considerable uncertainty about how climatic change will manifest at regional and local scales and with what intensity. We also know that different rural industry sectors, communities and individuals will have varying capacities to adapt. Furthermore, it remains unclear what degree of certainty and consensus there is in relation to what constitutes/will constitute 'effective' adaptation to climate change and how that knowledge can best be shared among interested and affected groups. These are all topics where social research can make a useful contribution.

In this review we draw on a substantial body of literature with a climate change focus, including that related to contemporary policy dialogues, the nature and influence of perceived risks, people's capacity to adapt to threats and communication and engagement. In undertaking this review we have set out to:

1. summarise recent social research examining wider public and rural landholder knowledge, attitudes and beliefs about climate change;
2. identify useful frameworks for describing and understanding rural landholder adaptation to climate change; and
3. suggest some principles to guide effective communication and engagement with rural landholders about climate change.

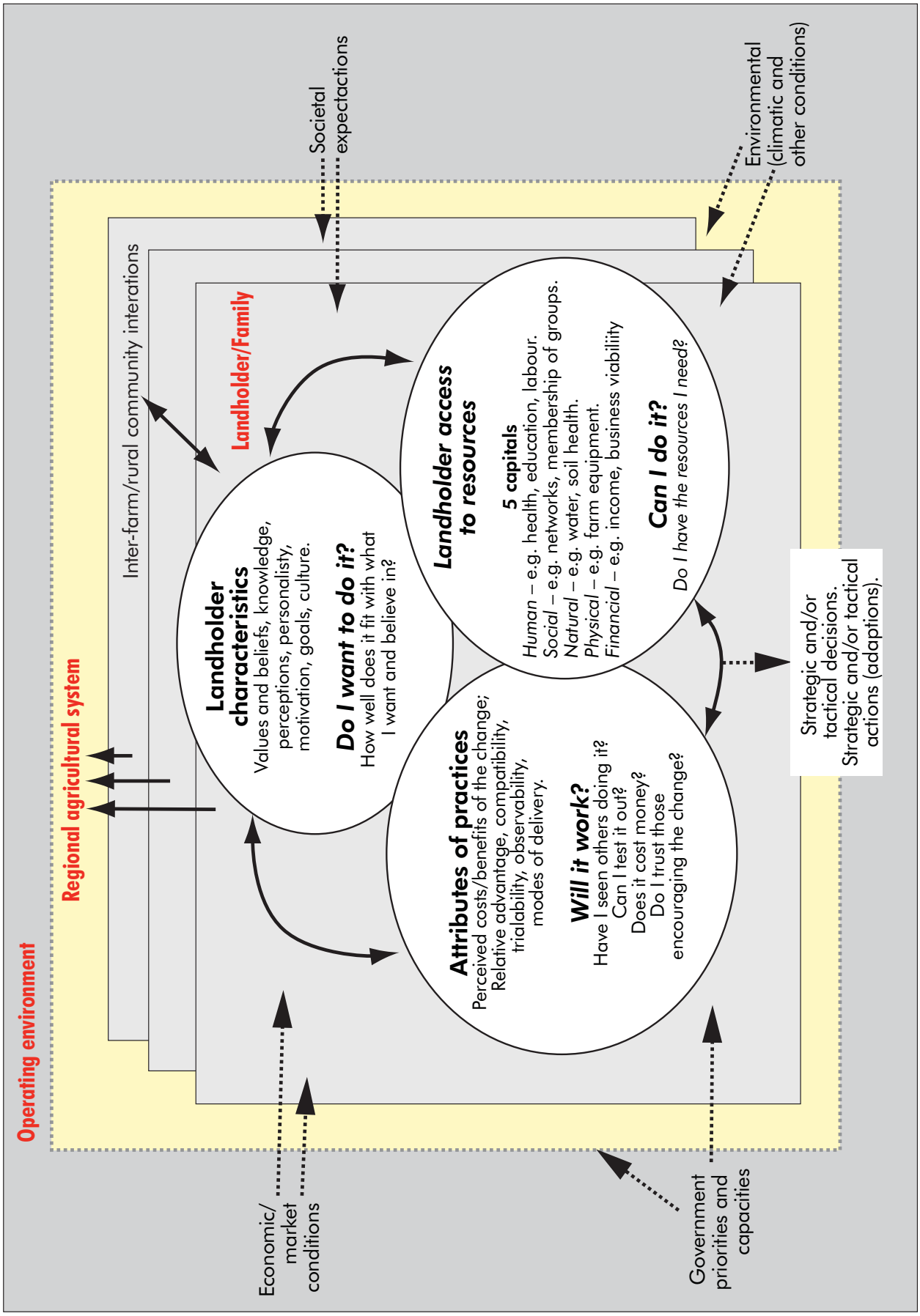


Figure 1. Factors influencing adaptation. Source: Adapted from Cary et al. 2002; Pannell et al. 2006; Pickworth et al. 2007; Nelson et al. 2006.

2. Climate change

Climate change is a serious issue facing all people of the world today. It is well established that the earth's climate is changing rapidly, the pace of that change has been caused largely by human activities, and those changes will have harmful effects on human activities and ecological systems. 'Climate change' is generally used to refer to changes in the Earth's climate caused by the greenhouse effect and global warming (IPCC 2007). While the greenhouse effect is a natural process, since the Industrial Revolution a range of human activities have increased concentrations of greenhouse gases (which normally absorb heat leaving the earth and return some of it), and those activities are contributing to a further warming of the Earth's surface. The Earth's temperature has already risen by approximately 0.7 degrees Celsius in the last 100 years, and is expected to increase further (1.0 degree to 6.4 degrees Celsius) by the end of the 21st century. This increase in temperature is expected to result in sea levels rising, as well as more frequent, widespread and/or intense weather events and extremes (e.g. heat waves, floods and storms, droughts, bushfires) (DCC 2008c).

Climate change impacts will manifest at a geographic level, with some regions experiencing greater pressures and vulnerabilities than others. Some of the more vulnerable areas (and associated communities) will be those already under significant stress, which have several climate sensitive industries or systems and/or have recognised national significance (Allen Consulting Group 2005). Some of these more vulnerable areas include low lying coastal population and resort centres; tropical and sub–tropical population centres; alpine regions; centres with a high dependence on agricultural and/or eco–tourism activities; remote Indigenous communities (particularly in the far north of Australia); areas of southern Australia facing acute water shortages and supply constraints (Allen Consulting Group 2005). Those regions identified include the Murray-Darling Basin, eastern Queensland, the Great Barrier Reef, the Australia Alps, the Kakadu wetlands, and south-west Western Australia (Hennessy *et al.* 2007; MCVP 2007).

2.1 The impacts of climate change on agriculture

There are significant implications for agriculture from the effects of climate change and variability. While agriculture is generally well adapted to mean or average climate conditions, it is particularly susceptible to irregular patterns or extreme conditions, particularly those that are expected to occur as a result of global warming (IPCC 2001 as cited in Burton & Lim 2005: 193). The agri-business units and regions considered most at risk are those:

- that are already stressed (economically, biophysically) as a result of land degradation, salinity, or loss of biodiversity;
- which are at the limits of their climate tolerance; and
- where substantial and long-term investments are being made (e.g. irrigation systems, slow growing cultivars, processing facilities) (Allen Consulting Group 2005).

The Australian Government's Department of Climate Change (DCC 2008b) has identified a range of expected (primarily negative) impacts on agriculture [Table 1]. In south-east Australia, the effects of a warming, drier climate with more frequent and/or intense extreme events is likely to have significant, negative economic impacts (e.g. lowering yields, increasing production risks) (George *et al.* 2005). Those impacts will manifest on farm, as well as having regional-scale impacts and flow-on effects where regions are heavily dependent on agricultural industries. The expected one degree increase in temperature and reduced rainfall over southern Australia is expected to have significant impacts on rain-fed and irrigated agriculture, and reduced rainfall could shift the eastern margins of the WA wheat belt (MCVP 2007). For other regions, there may be some opportunities for new agricultural industries (RIRDC 2007).

In Victoria, warmer temperatures, changing rainfall patterns, the fertilising effect of increased atmospheric carbon dioxide levels, increased demand for water and fewer frosts will affect agricultural productivity, the types of crops grown, occurrence of weeds and invasive species, and domestic and international markets (Jones & McInnes 2004). Dryland grazing and broad acre cropping is expected to suffer negative effects if warming is accompanied by decreased rainfall. Irrigated agriculture will need to increase water management efficiencies in the face of reduced water allocations, and warmer temperatures will create the need for reducing heat stress in livestock and new crop management techniques for horticulture. For the viticulture industry, higher temperatures could reduce grape quality but in cooler areas create opportunities for growing new varieties (CSIRO 2004).

Table 1. Expected impacts of climate change on different agriculture sectors. Source: DCC 2008b.

Intensive livestock	Increased heat stress of stock Increased effort to maintain animal health Reduced supply of feed – likely impacts on both the business's ability to produce pasture & crops and buy in grain Reduced reliability and quality of water supply to stock
Extensive livestock	Reduced pasture productivity Reduced herbage quality Changes to the dynamics of pests, diseases and weeds Increased soil erosion and nutrient movement into waterways Reduced carrying capacity Increased animal health and husbandry challenges Reduced reliability and quality of water supply to stock
Extensive cropping	Increased variability and changes to seasonality of rainfall Reduced soil moisture Changes to the dynamics of pests, diseases and weeds Increased heat shock/stress Reduced grain quality/nutrient content Increased yields in higher rainfall areas due to decreased incidence of soil water logging
Intensive cropping (horticulture, viticulture)	Decreased frost frequency (changes in crop selection to take into account vernalisation requirements, expansion of frost sensitive crops into current frost risk areas) Increased temperature & CO_2 (altered water demand, changes to sowing and harvest time) Altered range and incidence of pests and diseases Reduced quality (nutritional, appearance due to water/temperature stress, and increased CO_2 concentrations)

Since agriculture is particularly susceptible to irregular climatic patterns or extreme climatic conditions, climate change has significant implications for Australia's agricultural industries and regions. In South-east Australia, a warming, drier climate is expected with more frequent and/or intense extreme weather events. This trend is expected to have significant negative economic impacts on agriculture, which will generate other negative effects (social) at a farm and regional scale, particularly where those regions are heavily dependent on agricultural industries.

2.2 Key conversations about climate change

Today there appears to be growing acceptance among a range of individuals, groups, organisations, industries, and societies that 'climate change' is an important issue that requires our attention. Despite this seeming commonality, there is a plethora of diverse conversations in public and private settings about climate change. This is not surprising given that individuals from diverse backgrounds will have different values, attitudes and beliefs that will influence how they perceive and react to issues or problems they face. The way problems are perceived and 'framed' influences how these problems are understood, who participates in problem-solving and how, and what values will be favoured by actions and results (Bardwell 1991; Clark *et al.* 2000; Harding 1998; Swaffield 1998).

Several key features of the climate change 'dialogue' are discussed briefly below, including:

- the range of different terms used to refer to the warming of the Earth's temperature and its associated effects;
- key areas of uncertainty about climate change; and
- distinguishing between climate change 'mitigation' and 'adaptation'.

2.2.1 Climate change terminology

Language is an important part of environmental discourses – it is part of the construction, interpretation, discussion and analysis of conversations (Dryzek 1997). The dialogues about the phenomenon of the warming of the Earth's climate, implications of that warming, and required responses have been variously and sometimes interchangeably referred to as 'global warming', 'climate change', or 'climate variability'. As noted above, the IPCC (2007) defines climate change as any change in climate over time whether due to natural variability or resulting from human activity. Variability means apt or liable to vary or change, deviating from the usual type. Climate variability has been defined as irregular patterns or extreme conditions, such as more frequent droughts, deviations from normal growing season conditions (Smit and Skinner 2002).

The shift in formal usage by governments from the term 'global warming' to 'climate change' has been identified by sceptics as a strategy to neutralise the seriousness of the phenomenon (Lorenzoni

et al. 2006). In other cases, the interchangeable use of different terminology suggests there is confusion as to the meaning and relationship of terms to one another (Milne *et al*. 2008; McDonald *et al*. 2006). Other climatic phenomena such as 'drought' have also been challenging to define. Some social researchers argued earlier this decade that 'drought' needed to be recognised as a complex but 'normal' part of Australian agriculture – a consequence of a highly variable climate, where rainfall and high dry season temperatures fluctuate and should be referred to as 'climate variability' (Botterill & Fisher 2003; Lindesay 2003). Recent national dialogues position 'drought' as something that will be affected by 'climate change' – a projected two-fold increase in their frequency and severity (Hennessy *et al*. 2008).

The current National Drought Policy is being reviewed with a view to better preparing farmers, rural communities and Australia's primary industries for the challenges of 'climate change' (MAFF 2008). Yet, in drought affected areas in the Murray-Darling Basin there is evidence that while some people in rural communities see drought as something more 'normal' (a natural part of Australia's climate), they do not necessarily see it as resulting from (a human-induced phenomenon that is) 'climate change', and are often optimistic that the weather will return at some point to wetter conditions (Milne *et al*. 2008; McDonald *et al*. 2006).

2.2.2 Climate change uncertainties

Despite the varied use of such terms, there is increasingly high confidence among policy makers and the scientific community about certain aspects of climate change. According to Moss (2007) those aspects include:

- the actual occurrence of human-induced climate change;
- improvements in climate modelling;
- understanding the potential impacts of climate change under different scenarios;
- understanding the requirements for successful adaptation and mitigation options; and
- knowledge about what constitutes 'dangerous' human interference in the climate system.

At the same time, there is some disagreement about these matters. Some researchers believe that risk assessments of climate change tend to be overly technical, lacking input on the social and psychological qualities of hazards, and are therefore often contested by different interpretive communities (e.g. scientists, special interest groups, and political elites) (Leiserowitz 2005; Stedman 2004; Slovic 1999; Pidgeon *et al*. 2006).

There are other formal and informal dialogues that continue to reflect a range of uncertainties about the nature of climate change, its specific impacts, and what constitutes appropriate responses. This is not surprising given that uncertainty is an inherent feature of environmental problems and arises at many points in the decision-making process due to extended time scales, complexity, competing values and knowledge, and a lack of information (Dovers *et al*. 2008 as cited in Smithson and Bammer 2008; Harding 1998). Smithson (2008) noted that while uncertainty is not always a negative aspect of human affairs, it does present genuine dilemmas for modern society. He believes that our interest in uncertainty comes from regularly facing key adaptive challenges, which include how to:

- deal with unforeseen threats and solve problems;
- benefit from opportunities for exploration and discovery;
- craft good outcomes in a partially learnable world; and
- deal intelligently and sociably with other people (Smithson 2008: 20).

Smithson and Bammer (2008: 322) assert that coping with and managing uncertainty is typically oriented towards how uncertainty can be better understood; represented, quantified or estimated, and communicated; eliminated or reduced; accepted or tolerated; and controlled, harnessed or exploited. They also note that uncertainty strategies often involve a (sometime conflicting) mix of motivations and adaptive challenges, and that there is no single recipe for dealing effectively with uncertainty. These learnings are readily apparent in modern society's efforts to understand and better manage climate change.

Climate change uncertainties have been classified as ecological, knowledge and livelihood (Dessai *et al*. 2007). Some of the key topics of uncertainty include:

- how the climate will change, particularly at regional and local scales;
- the extent climate change will appear as gradual changes in climate averages or as abrupt or stepped changes;
- defining the limits and thresholds beyond which changes in climate systems might be deemed unacceptable;
- how regional variations in impacts and regional adaptive capacities will manifest;
- how – in combination with technological, economic and social changes already affecting agriculture – industry will be affected by climate change; and
- the relationship between climate change and drought (e.g. increased incidence of more severe droughts in Australia).

Dessai *et al*. (2007) argued that despite the

pervasive nature of uncertainty in climate change, insufficient effort is made to systematically assess what it means for the many dimensions of climate change analysis and action. They and others (see Harding 1998) argue that too much emphasis is placed on reducing uncertainty through climate science and prediction, while we neglect a wider examination of the myriad effects of uncertainty on how individuals, organisations and societies respond to climate change – which will have serious implications for long term sustainability. Similarly, while Lorenzoni *et al*. (2005) consider the climate science community's efforts to reduce uncertainty around dangerous impacts is laudable, they believe other considerations are just as important in determining appropriate action – namely, what society or individuals will ultimately deem to be acceptable or unacceptable risks from climate change.

2.2.3 Mitigation and adaptation

In considering appropriate responses to climate change, policy makers and the scientific community have identified two main options: mitigation and adaptation – both concepts consider ways to reduce the negative effects of a changing climate[1]. Many decision-makers, researchers, and interest groups see mitigation and adaptation as necessary and complementary strategies for responding to climate change (see COAG 2007; Victorian Government 2007; UNFCCC 2006).

Climate change 'mitigation' is about seeking ways to moderate the effects of climate change by taking actions to reduce greenhouse gas emissions or sequester carbon in soils and biomass (Burton & Lim 2005). Climate change 'adaptation' is essentially about making process, practice or structural adjustments to (human and natural) systems in order to moderate damage from, take advantage of opportunities provided by, and/or cope with the consequences of climate change (IPCC 2001 as cited in Burton & Lim 2005). A key assumption underpinning conversations about climate change adaptation is that a certain amount of climate change is inevitable and that society can (and should) take steps to minimise losses (Grothmann & Patt 2005; DCC 2008a).

Climate change adaptation is now a standard response intended to reduce the vulnerability of groups and to minimise costs of impacts. In Australia, The Climate Change Adaptation Programme was launched in 2004 in order to increase assessments of climate change impacts and further dialogues around adaptation (Preston *et al*. 2008). By 2007, the National Climate Change Adaptation Framework (COAG 2007) had been formulated, outlining strategic government actions on climate change adaptation for the next 5–7 years. A key focus of the Framework is to support decision-makers by filling the knowledge and information gaps[2] that are believed to have constrained more definitive and effective adaptations at the national and regional levels to date. In addition to building knowledge capacity, the Framework seeks to reduce the vulnerability of key sectors and regions[3] to climate change by developing sector-specific tools, information, and climate change action plans.

A plethora of actors around the world are having diverse conversations about the climate change 'problem(s)'. Participants in those conversations have different understandings of and uses for the various terms used to refer to the rising of the Earth's temperature and its associated effects. This diversity of knowledge and language suggests there is confusion and disagreement about the meaning of, relationship between, and the implications from the phenomena of 'climate change', 'climate variability', 'global warming', and 'drought. While there is increasing certainty among many sectors of the international community about the occurrence of human-induced climate change and some of its potential impacts, considerable uncertainties remain.

Uncertainties are an inherent feature of environmental problems like climate change. And climate change is presenting some genuine decision-making dilemmas for modern society – not least of which is how to better understand and thereby reduce the uncertainty over how (and how quickly) the climate will change at regional and local scales, and with what specific environmental, economic and social effects. Yet some are suggesting that less effort is needed on reducing these uncertainties and a greater focus should be placed on how we determine what are socially-acceptable levels of risk from climate change and what are appropriate responses to those risks. International and national policy and research dialogues position climate change 'mitigation' and 'adaptation' as different but complimentary strategies for responding to climate change.

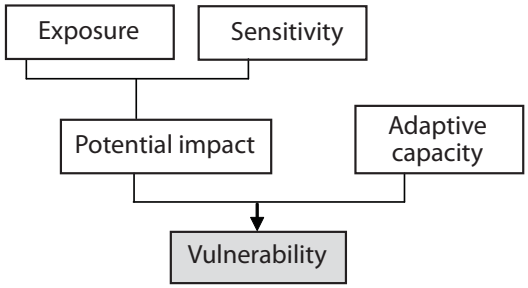
2.2.4 Agriculture and adaptation to climate change

In climate change research and policy dialogues 'adaptation', 'vulnerability' and 'resilience' are key concepts that are often defined in a range of ways by different actors (Vogel *et al*. 2007; Janssen *et al*. 2006). These terms are discussed using varying degrees of specificity, reference to the relationships between the terms, and at different spatial scales. Some have suggested that these competing conceptualisations and terminologies interfere with the efforts of multi-

disciplinary research teams to communicate clearly and transparently when collaborating on climate change problem-solving (Fussel 2007; Preston *et al.* 2008). Others suggest there is increasing integration across these different 'knowledge domains' (Janssen *et al.* 2006).

Adaptation has been described as a dynamic process of adjustments in ecological-social/political-economic contexts of agricultural systems, which reduces the vulnerability of agricultural sectors and/or farms to climate change effects, many of which are experienced in economic terms (e.g. reduced yield, increased operating costs) (Smit & Skinner 2002; Reid *et al.* 2007; George *et al.* 2005)[4]. In the context of agriculture, those taking a systems perspective tend to see 'vulnerability' as being central to adaptation to climate change, although Preston *et al.* (2008) note the debate within the climate change community regarding the ultimate meaning of the term. A diagrammatic representation of the relationship between these elements that is regularly referred to in (national) climate change dialogues is shown in Figure 2 (Allen Consulting Group 2005).

Figure 2. Elements of vulnerability.



Source: Allen Consulting Group 2005.

Generally speaking, when someone or something is 'vulnerable', they/it are especially liable to or subject to succumb to some – usually negative – influence, often the capacity to be harmed or wounded by some hazard or threat (Thywissen 2006; Fussel 2007). The IPCC Third Assessment Report (Fussel 2007) defines vulnerability as:

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.

Similarly, Reid *et al.* (2007) suggested that an agricultural systems' vulnerability to climate change is determined by its:

- *exposure sensitivity* – the susceptibility of a system to be affected by stimuli + interaction of characteristics of the stimuli (climate conditions) relative to the agricultural system; and
- *adaptive capacity* – the potential or ability of a system, region, community to adapt to effects or impacts of climate change.

Preston *et al.* (2008) note that these definitions emphasise the potential for harm from being exposed to the (hazardous) impacts of climate change and the social dimensions of vulnerability, which are manifest in coping or adaptive capacity. Fussel's (2007: 164) analysis of the IPCC definition of 'vulnerability' adds temporal considerations to exposure and sensitivity, namely the need to consider the future risk from global climate change which is determined by:

1. the future hazard level;
2. (current) sensitivities;
3. (dynamic) adaptive capacity; and
4. regional exposure factors.

Climate change is essentially a long term challenge. The level of hazard posed will vary depending on regional characteristics and adaptations will take time to develop and will evolve over time.

Another dimension of the conversations about adapting to climate change is how to define 'resilience' and 'adaptive capacity', understand how they are related to each other, and determine how these terms might best be applied. 'Resilience' tends to emphasise the ability to resist damage, while 'adaptive capacity' emphasises the ability to change (Preston *et al.* 2008). Nonetheless, there is considerable overlap and similarity in these terms – both suggesting some type of positive capability in the face of largely negative impacts. For example, some consider that *adaptive capacity* is a key element of *resilience* (Tschakert 2007), others tend to see resilience as a determinant of *adaptive capacity* (Folke *et al.* 2002), while still others fail to make such distinctions and tend to use the terms more or less interchangeably.

Resilience is often used to describe the ability to recover from (or to resist being affected or changed by) some shock, insult or disturbance. It is a highly complex, dynamic phenomenon composed of multiple, interrelated dimensions which fluctuate over time (Hegney *et al.* 2007). In ecology, *resilience* refers to the ability of a system to absorb shocks/sudden changes and disturbances, in order to avoid crossing a threshold into an alternate and possibly irreversible new state, and to regenerate after disturbance (Kinzig *et al.* 2007; Tscharkert 2007).

Adger *et al.*'s (2002 as cited in Marshall & Marshall 2007) definition of social resilience borrows from ecology. They also take a systems view: the ability of communities to cope with external stresses and disturbances as a result of social, political and environmental change and maintain the sustainability of their livelihoods.

In contrast, psychological perspectives on resilience tend to have a smaller scale focus – and consider the positive capacity of individuals to cope

with stress and catastrophe, and of resistance to future negative events[5] (Rutter 2000). Individuals are 'resilient' when they demonstrate positive behavioural adaptations (social competence/success at meeting tasks at a specific life stage), when they encounter adversity or trauma (risks associated with negative life conditions creating adjustment difficulties)[6]. Psychology dialogues position vulnerability as particular risk factors (low intelligence, socio-economic status) in some people's lives that may increase the difficulty of adjusting to certain situations. Vulnerable people are those who are less resilient – they have difficulty making adjustments in their lives (adapting) when experiencing changes, and are therefore less able to maintain stability or grow.

Steffan *et al*. (2006) define *vulnerability* as the degree to which producers, industries and rural communities have the *capability to adapt* to climate change. Like Tschakert (2007), they suggest that *resilience* is the inverse of vulnerability – it determines whether the agricultural sector (and presumably farm businesses and farm managers) can deal successfully with climate risks. Vulnerable areas and industry sectors can be identified by looking at a range of biophysical and social factors, including their level of exposure from changing climate; sensitivity to climate risks; and adaptive capacity.

Vulnerability research, typically aimed at reducing *vulnerability*, seeks to increase resilience *and* adaptive capacity. Some of this work uses a hazards perspective and draws on sociological theory. For example, O'Neill (2004) defines *vulnerability* as a measure of the potential for (hazardous) events to damage the resources of a community. In this case, *resilience* is the measure of the community's *capacity to adapt* (prevent and resist such damage), and if it does occur, recover successfully. O'Neill places most emphasis on community capacity – the functioning of groups and networks in time of disaster versus that of individuals' capacity – when seeking to improve adaptive capacities. Others consider the importance of individual resilience as a sub-component of community capacity, which includes people's perceived self-efficacy, coping styles, access to social networks, sense of belonging, and collaborative skills (Pooley *et al*. 2003 as cited in O'Neill 2004).

Some research in the area of rural sustainability overlaps with hazards approaches – it also considers *vulnerability* and *resilience* as important determinants of communities' capacity to adapt to hazards, but also to other types of stressors. In this instance, vulnerability refers to how societies or socio-economic groups will be affected by different external hazards or internal and external stressors that have negative impacts on the social cohesion of a community (Brooks 2007).

Another important focus of climate change dialogues is on agriculture and adaptation to climate change. There has been considerable discussion about how agricultural adaptation to climate change should be defined, what are its distinguishing characteristics, what factors drive or constrain it, how it should be evaluated, and how it can be encouraged at different scales.

A common conception of agricultural adaptation to climate change is that it is a continual process of adjustment that reduces vulnerability of some entity to climate change effects. Depending on the research discipline and/or primary area of interest, that entity exists at different scales – biophysical and/or social-economic systems, agricultural industries, regions, communities, or individuals. What determines vulnerability is also subject to varying interpretations, but is generally accepted as something that – when exposed to some kind of influence – is especially likely to succumb to some kind of (negative) impact. The severity of that impact will be moderated by the entity's 'resilience' and/or 'capacity to adapt'. 'Resilience' is often used to refer to the ability to recover from or resist damage, while 'adaptive capacity' emphasises the ability to change. Nonetheless, there is considerable overlap and similarity in these terms – both suggesting some type of positive capability in the face of largely negative impacts. Different research disciplines will seek varying indicators of vulnerability, resilience and adaptive capacity.

2.2.5 The quality of adaptation to climate change

Many of the conversations about climate change effects on agricultural industries (and rural communities) carry a note of optimism. It is assumed that because agriculture is inherently sensitive to variable climatic conditions, those involved (producers, etc.) have already been making numerous (historic, current) adjustments to mitigate adverse conditions and take advantage of opportunities (Preston *et al*. 2008; Campbell 2006; Steffan *et al*. 2006). The agricultural industry and its associated communities are seen to have a fundamental or baseline capacity to adapt to future climate change and variability, and can do so in part by drawing on some of the changes that have already been made.

DCC (2008b) have recommended a range of broad actions to assist agricultural adjustments to climate change [Appendix 2]. Others have used a range of characteristics to identify different aspects of climate change adaptation in agriculture [Table 2].

Table 2. Defining characteristics of climate change adaptations.

Category	Description
Form and type of adaptive measure	Technological developments, government programs and insurance, farm production practices, farm financial management
Degree of intent and purpose	Degree of spontaneity, part of ongoing management, part of response to climate risk
Timing/temporal scale and duration of use	Anticipatory/proactive, concurrent/during, responsive/reactive, tactical/shorter term versus strategic/longer term
Timing (in relation to some kind of threat)	Pre-risk/anticipatory: risk reduction; pre-risk/during risk: risk hedging or risk transfer; post risk/reactive: risk mitigation
Relationship to other climate change management processes	Scale, responsibility/roles of different actors – farm business managers, policy-makers
Other	Those targeting generic vulnerabilities (broad spectrum actions providing benefits to numerous institutions); those targeting individual systems, processes, activities

Source: Adapted from Smit & Skinner 2002; Reid et al. 2007; Preston et al. 2008.

It is also worth considering the research and policy dialogues about the quality of adaptation (in agriculture and other contexts), namely its 'effectiveness'. The term 'adaptation' generally carries a positive connotation: that is, if one 'adapts' in the face of change, that is necessarily a good or appropriate response; and if they do not, this is undesirable. Preston *et al.* (2008: 12) refer to adaptive capacity as the ability to change in a way that makes it ''better equipped'' to manage exposure or sensitivities to climatic influences.

Some adaptations may be considered insufficient in some way – if they fail to achieve an improved ability to manage climate change impacts or take advantage of any opportunities. For example, a study of some members of rural communities found that they were concerned that farmers' use of drought management strategies as their primary climate change risk management strategy will be inadequate to address new and evolving conditions of lower rainfall, higher temperatures and more extreme weather (Milne *et al.* 2008). In these cases, there was a sense that people were 'coping' rather than proactively managing for climate risk (Milne *et al.* 2008; see also Wehbe *et al.* 2006) and an implicit judgement that anticipating the risks is more effective than waiting for the impacts to occur or simply making routine adjustments.

Finally, the inverse of 'adaptation' would be 'mal-adaptation', and it takes the notion of less-than-effective adaptations one step further. 'Mal-adaptation' has been used to refer to decision-making that makes some entity (an activity, individual, group, or region) more vulnerable to climate change than before that decision was taken (DCC 2008d).

How well placed are we to assess the quality of adaptations to climate change? Burton & Lim (2005) suggest that there are considerable uncertainties in the climate projections themselves and that assumptions are being made about the likely success of adaptation on the basis of limited research. In Australia, there remains a lack of well-developed evaluation tools for assessing planned adaptation options for climate change in local/regional areas (Preston *et al.* 2008; Hennessy *et al.* 2007). What seems more certain is that adaptive strategies and behaviours will vary regionally in the extent to which they help prevent and/or mitigate damage and/or create opportunities (see Niemeyer *et al.* 2005; Grothmann & Patt 2005; Adger 2000; Burton & Lim 2005).

Undoubtedly, further dialogues are needed among the research and policy communities and other communities of interest about:

- what constitutes appropriate and/or effective climate change adaptation;
- what evaluation criteria can/should be applied to determine different levels of effectiveness over what temporal and spatial scales;
- which actors and communities of interest should be responsible for such evaluations; and
- how such learnings should be shared.

Some climate change dialogues are optimistic about agricultural industries' baseline capacity to adapt to future climate change impacts, given the numerous historic adjustments that have been made in the face of (climatic and other) forces. Generally speaking, adapting to climate change is seen as a good thing, while not adapting is negative. There are multiple ways to describe and classify climate change adaptations in agriculture, and governments and scientists have made general prescriptions for climate change mitigation and adaptation in agriculture. However, Australia lacks well-developed evaluation tools for assessing the quality of different climate change adaptations in agriculture, particularly at the regional and local scales.

3. The 'risk' in climate change

Risk is very topical in contemporary society, and is therefore an important concept in many policy areas. Risk is central to environmental and natural resource management policy responses to climate variability, climate change and drought. These largely uncontrollable, chronic phenomena present society with a range of – primarily negative – actual and potential consequences, uncertainties about the timing and extent of those effects, and therefore difficult choices about how best to assess and manage climate risk in order to mitigate negative impacts and create opportunities for positive outcomes.

Terms like "risk analysis" and "risk management" tend to assume a degree of shared understanding of the concept of risk, acceptance of how it is measured, as well as some level of consensus on how it should be managed in these settings. Yet, a closer look reveals more ambiguous and complex realities around 'risk'. Risk is in fact socially-constructed (Slovic 1999). That is, 'risk' does not exist 'out there,' independent of our minds and cultures, waiting to be measured. Human beings have invented the concept of risk to help them understand and cope with the dangers, opportunities and uncertainties of life. All people, irrespective of their role in society use speculative frameworks to make sense of the world and selective judgements in their responses to risk (Slovic 1999). In addition, there are significant differences in these understandings and responses, and such divergences are critical to understanding how best to manage and communicate about risk.

There is a range of nuances associated with and emphases placed on the term 'risk'. These nuances vary from risk as a wager individuals take in the hope of gaining something significant (Graubard 1990), to risk as the possible loss of something of value (Blomkvist 1987). Some emphasise risk as a future-oriented concept (Adams 1995). Generally speaking, the risk concerns pervading modern society generally do so in a negative tone (risk as something to be feared), and are less often seen as something neutral (uncertainty about outcomes of choices) or positive (the potential benefits of risk behaviour – entrepreneurship, active citizenship, competitive sport) (Taylor-Gooby & Zinn 2006; Palfreman 2006). One of the more commonly used definitions of risk is:

Risk = [**Frequency** or **Probability** of occurrence (of a defined hazard)] + [(magnitude of) **Consequences:** how often is a particular, potentially harmful event going to occur, and what are the consequences of this occurrence?]

(Harding 1998; Palfreman 2006).

3.1 Approaches to understanding risk

Social scientists have successfully argued that 'risk' does not just embody probability and consequences of real world events, which are the focus of engineering and technical studies. How people perceive and respond to risk events are just as relevant (Palfreman 2006). Risk research draws on numerous social science disciplines including behavioural economics, psychology, social psychology, and sociology [Appendix 3]. These works have generated numerous insights into how people perceive, manage, and live with 'risk', and those learnings are directly and indirectly relevant to understanding how society responds to climate change.

Social science risk research spans a wide spectrum. According to Taylor-Gooby & Zinn (2006: 10) this wide-ranging, interdisciplinary work evolved from positions resting on three core disciplinary presuppositions:

- economics – rational actor approaches;
- psychology – the individual as the basic building block for analysis; and
- sociology – studying culture and institutions as the key determinant of risk.

These basic ideas closely correspond to the different scales at which social science risk research is undertaken:

- macro-level – understanding risk and uncertainty as primary elements in modern culture;
- intermediate level – how risks should be managed by institutions and organisations in publicly acceptable ways; and
- micro-level – accounting for the ways people respond to risk in complex contexts (Zinn & Taylor-Gooby 2006: 54).

Drawing from *psychology's* focus on individuals and economic's focus on rationality, cognitive psychology and behavioural economics have generated numerous theories on various decision-making phenomenon and tools employed by individuals in relation to risk [Appendix 3]. Early work looked for universal laws of decision-making to explain how and why people might deviate from the 'best' (rational) risk calculations, and contributed to the development of ideas such as heuristics, framing and mental models. For example, the work of Tversky and Kahneman (1974) suggested that people rely on a limited number of shortcuts for making decisions about risk, and these can lead to 'inaccurate' judgements in some situations, in which case they become cognitive biases. These researchers identified an availability heuristic, which operates when people assess the probability of an event occurring according to how readily it (or something similar) can be recalled (Taylor-Gooby & Zinn 2006).

Risk research in the *social psychology* tradition draws on cognitive psychology, but also considers common features across a wide range of risk perceptions and responses [Appendix 3]. Here, the focus is widened to consider the influence of some cultural factors on the way risks are perceived. There is strong interest in the extent to which particular risks are familiar and provoke varying degrees of dread. For example, work within the psychometric paradigm focused on the perceived characteristics of the risk source or risk situation, as well as beliefs and attitudes about the nature, consequences, history and justifiability of a risk. Prominent researchers found that risks with low probability but high consequences were perceived as more threatening than more probable risks with low or medium consequences (Rohrmann & Renn 2000). Eventually prominent risk researchers, such as Paul Slovic, developed a two dimensional structure to explain why and how people's judgements about risks vary, based upon:

- the severity or dreadfulness of the hazard (e.g. terror, lack of control, involuntariness, concern for future generations); and
- knowledge of hazard (e.g. degree to which risk is known, observable, new/familiar) (Zinn & Taylor-Gooby 2006).

Strictly *sociological approaches* to risk can be distinguished from work in psychology, economics, and social psychology in that they seek to explain risk more in terms of societal structures than individual level factors [Appendix 3]. This work distinguishes between different kinds of knowledge among societal groups (e.g. experts and their lay audiences), which are predominantly influenced by their culture, professions, social groups. Douglas and Wildavsky (1982) suggest that risk perceptions are produced by, and support social structures (e.g. fears of certain risks maintain social structure). They and other cultural theorists have scored individuals on four 'cultural biases' or scales (hierarchy, individualism, egalitarianism, fatalism) that correspond to certain social structures and risk perceptions, which are in turn defined by the degree to which people are restricted in their social roles and their sense of belonging to particular groups (Langford 2002) [Table 3].

Table 3. Cultural biases on risk perceptions. Source: Langford 2002.

Hierarchical	Strong group boundaries and binding prescriptions Individual's place in life defined by institutional classifications (e.g. age, gender), which enable smooth running of society Control vested in formal, hierarchical systems of authority Greater concerns about risks that might disrupt societal order
Egalitarian	Strong group boundaries and sense of social connectedness Individual negotiate relations with others Stronger concerns about low-probability/ high consequence risk situations (e.g. nuclear power)
Individualism	No group incorporation or prescribed roles Lower sense of responsibility to other members of society High concerns about risk that might impair market functions (e.g. war)
Fatalism	Low group associations but strong sense of distinctiveness Predominant view of lack of control, excluded from institutions Low risk concerns Focus on adapting to consequences of risk

Other important sociological work considers the qualitatively different kinds of risk that are part and parcel of modern society and the best institutional structures and forms of decision-making that lead to improvements in public trust and the acceptability of public risks [see Appendix 3]. When Beck (1992) coined the phrase 'risk society', he was suggesting that the very structure of modern society was organised in response to risks. Humans have always faced natural kinds of risks (external), but modernisation has produced a range of risks that are the product of human activity (manufactured risk) (Giddens 1999). In a risk society, there is greater focus on 'manufactured' risks – assessing levels of risk and focusing on ways to control and/or prevent them. Beck was also interested in how risks are distributed unevenly across society, where those with greater knowledge (and sometimes resources) are better able to avoid the negative consequences of certain risks (e.g. pollution). Alongside – and perhaps partly as a result of – such inequities is a tendency for lower trust in industry, governments, and experts.

While they have some limitations [see Appendix 4], all these ideas have contributed to an improved understanding of risk. Zinn and Taylor-Gooby (2006: 54–56) see a need for continued interdisciplinary work to address three main developments/issues/ agendas in risk research:

1. In any complex society relying on new and untried technologies, risks cannot simply be understood as technical issues that can be eliminated with the 'right' systems. The issue is much more about managing acceptable levels of risk.
2. Hence, a wide range of political issues about trust in authorities, experts, and officials, about social communication and the mass media remain important. Decision-making must become more inclusive and participatory to build trust.

3. Broader consideration is needed of the complexity of everyday risk decisions. Social identity and group membership influence risk taking and avoidance. As risk is more complex than 'rational' judgement, it is important to account for the emotional factors (anxiety, stress) which drive choices.

In meeting Zinn and Taylor-Gooby's (2006) plea for interdisciplinary research, future work on climate risk and adaptation in agriculture would need to include work at different scales, drawing on approaches developed in psychology, social psychology, and sociology. Irrespective of the specific methods applied, this would include recognising and attempting to account for the range of factors influencing risk perceptions and responses and use of agricultural innovations as previously noted by Wejnert (2002: 297), including:

- characteristics of individuals (e.g. psychological traits, socio-demographics);
- characteristics of the risk or practice in question; and
- characteristics of social and environmental contexts in which actors and risks are embedded (e.g. political conditions, geographical settings, culture).

Human beings invented the notion of 'risk' to help understand and cope with the dangers, opportunities and uncertainties of life. Contemporary definitions typically position 'risk' as something more negative than positive: the frequency or probability of occurrence of potentially harmful events plus the magnitude of the consequences. Since 'risk' is socially constructed, it is possible to identify patterns of similarity and difference in the way people perceive and respond to different kinds of risks. The social sciences (particularly psychology, social psychology, sociology) have provided valuable insights about patterns of individual risk decision-making; the different kinds of knowledge about and responses to risks among societal groups; and how institutional structures and forms of decision-making position and influence risk in society.

3.2 Public perceptions of climate change risks

Recent international research has examined public opinion about climate change and its associated risks and impacts. This work looks at whether people believe in climate change and how much they understand its effects. The research also examines people's views about what priority should be given to addressing climate change and their levels of support for different climate change policies.

In a synthesis of four multi-country surveys[7] undertaken in 2006, Brewer (2007) determined that:

- substantial majorities in all countries were aware of climate change and considered it to be a serious problem, with the level of concern up considerably since 2003;
- the US, China and the UK had the lowest proportions of people who felt personally concerned about climate change; and
- substantial majorities see current ways of producing and using energy to be problematic, with widespread support for tax incentives for alternative fuel sources and requirements for increased auto fuel efficiency.

Researchers have also detected considerable misunderstanding regarding the 'facts' about climate change, such as conflating climate change with the hole in the ozone layer (Lorenzoni *et al*. 2006; Palfreman 2006; Stedman 2004). Few members of the public had associated climate change with extreme weather events, such as floods and hurricanes (Leiserowitz 2005). While Dietz *et al*. (2007) found that two-thirds of respondents believed that climate change would bring about a rise in health problems and loss of species and half thought there would be negative impacts on living standards, other research has found somewhat different views. Generally, people tend not to see themselves as personally at risk (in the near future/short term, from impacts on health) (Sunstein 2007; Lorenzoni *et al*. 2006; Leiserowitz 2005). This lack of concern may be due to global warming being seen as uncertain, controversial, far into the future, out of public hands (Moser & Dilling 2004) – essentially a moderate risk that will predominantly impact on geographically and temporally distant places (Lorenzoni *et al*. 2006; Leiserowitz 2005)[8].

US studies provide some evidence that the public is willing to support policies to mitigate climate change, although that support is typically contingent upon perceived convenience, personal benefits, and trust in government (Dietz *et al*. 2007; Lorenzoni *et al*. 2006). Their support tends to be more parochial, people are more willing to pay to repair the effects of global warming 'they' (created by residents of other rich nations but not for humans generally) have inflicted (Baron 2006). Generally, the surveys show that climate change and environmental issues are seen by the public as lower national priorities, and climate change as a lower priority environmental issue (Lorenzoni *et al*. 2006; Leiserowitz 2005). Researchers note that despite growing scientific consensus, large parts of American society remain in denial about the reality and seriousness of climate change, and that kind of psyche will fail to generate the momentum required to address climate risks (Bazerman 2006; Weber 2006; Moser & Dilling 2004).

In Australia, recent opinion polls suggest that climate change is a central concern amongst a majority of the public. In a Research Australia (2007) poll, 83% of respondents indicated they believed that climate change is real; and slightly less than half (45%) felt that environmental problems like those that might be caused by climate change may have affected their health. A 2007 poll by the Lowy Institute (Gyngell 2007: 15–16) found that Australians rated climate change as the most important external threat faced, and believed that tackling it should be the most important foreign policy goal for Australia. In relation to domestic priorities, climate change was nearly as important as improving education. Power *et al.* (2007) drew partly on the Lowy Institute's findings to suggest that public opinion on climate change has been broadly aligned with scientific consensus and reaching a tipping point in the last two years – shifting into great concern about the phenomenon and its impacts.

Recent Australian and overseas social research has identified a relatively high level of public awareness of climate change and its negative impacts. However, there is also considerable public misunderstanding about aspects of the science underlying climate change and some people are confused about the exact nature, causes, and consequences of climate change. While there is broad public support for a range of mitigation policies, many people still don't see climate change as a personal threat.

3.2.1 Factors influencing public views on climate risks

As noted earlier, social scientists have identified a range of psychological, social, cultural and institutional factors that influence how people perceive and respond to different kinds of risk [Appendix 3]. The research above draws on cognitive psychology, social psychology and sociology to identify how socio-demographic factors, heuristics, affect and emotion, the characteristics of climate change, cultural influences, the media, and organisational, political and institutional factors shape public views on climate change. Those findings are reviewed below.

3.2.1.1 Socio-demographic factors

The effects of demographics on climate risk perceptions are unclear. Generally, demographic factors are thought to have an indirect influence on the perceived salience of climate change – tending to influence general worldviews/beliefs, which in turn inform people's beliefs about climate change (Dietz *et al.* 2007; Stedman 2004). Greater support for climate change mitigation is associated with higher levels of education (O'Connor *et al.* 1999, 2002) and income levels, particularly where costs might be imposed on households (O'Connor *et al.* 2002). Dietz *et al.* (2007) and Stedman (2004) suggest that the effects of age and gender on support for climate change action are not definitive, although in Stedman's (2004) study, women did show greater concern about climate change.

3.2.1.2 Psychological factors

Social scientists have examined numerous mental processes that underpin people's views and positions relating to climate change. This research looks at how particular attributes of climate change, people's awareness and knowledge of climate change, and the various heuristics they employ when thinking about global warming and climate change inhibits or encourages them from supporting mitigation policies or taking personal mitigation actions.

O'Connor *et al.* (2002) found that those who understood the causes of climate change were more likely to support reducing greenhouse gas emissions. They assert that those believing that global warming is likely to occur and to have serious, negative consequences for humans and non-human nature, and who had strong environmental values were also more likely to support mitigation. Understanding and knowledge seems central to positive climate change responses – and that understanding may relate to the quality and accessibility of the scientific information and concepts underpinning environmental issues like climate change. Lorenzoni *et al.* (2006) suggest that some of the public often confuse global warming with the hole in the ozone layer, because the ozone hole is a well-established concept, easy to imagine and remember, and it has often been linked to climate change by popular information sources. Lorenzoni *et al.* (2007) found that barriers to public action on climate change were caused by a lack of basic knowledge about its causes, impacts, and solutions. They found that where climate change information was available, the lack of uptake by some was due to their lack of motivation, a sense of information overload, and confusion over conflicting information.

Affective images can interact with a lack of knowledge and certain beliefs to dissuade people from seeing the threat of climate change. In the US and UK, the terms 'global warming' and 'climate change' evoke primarily negative connotative meanings for people, although they tend not to relate to it personally or to associate it with its causes or solutions (Leiserowitz 2005; Lorenzoni *et al.* 2006). Others have looked at more primal forces driving people's non-response to phenomena like climate change. Moser and Dilling (2004) point to evolution to partly

explain why people have a limited attention span to devote to non-immediate problems, versus having to respond or react to more immediate threats. They asserted that this basic instinct might partly explain why the majority of Americans have heard of 'global warming', but a much smaller percentage is personally concerned about it: it is not seen as an immediate threat.

Weber (2006) applied the psychometric paradigm to understand the influence of affect and emotion on people's perceptions and responses to climate change. She notes that worry is a key driver of risk management decisions – people who are not alarmed about a risk/hazard tend not to take precautions. Weber (2006) also looked at how personal experience strongly influences the evaluation of risk options. When people base their decisions on statistical descriptions about a hazard provided by others – the hazards' characteristics are strong predictors of different degrees of worry or alarm. Personal experience with noticeable and serious consequences of global warming is still the exception.

The characteristics of climate change are an important influence on people's responses to it. Weber (2006) describes the time-delayed, abstract, and statistical nature of global warming risks and how they have failed to evoke strong visceral reactions. Furthermore, she states that where people see climate change as simple, gradual (versus more intense and rapid), well known and therefore controllable, the incentive for widespread corrective action is reduced (Weber 2006).

Like Weber (2006), Moser and Dilling (2004: 34) also looked at the characteristics of climate change and refer to it as a ''creeping environmental problem''. Such hazards tend to be long-term in nature, have a slow-onset (at least initially), and are essentially cumulative processes that ultimately can result in crises or disasters. Climate change is therefore difficult to pinpoint, understand, manage, and succinctly explain. While scientists frequently emphasise the complexities and uncertainties of climate change, a typical lay audience often finds this information hard to comprehend and often turn to pre-existing, simplifying mental models to help them understand global warming. Some of these heuristic devices do not adequately capture the complex relationship between the causes, impacts and solutions to global warming (Moser & Dilling 2004).

Bazerman (2006: 179) sees climate change as a 'predictable surprise' – an event that leads organisations, nations, or individuals to react with surprise, even though information needed to anticipate the event and its consequences has been available for

Table 4. Cognitive deterrents to support of climate change mitigation

Cost benefit analysis & parochialism	
Climate related events tend to be interpreted in an ego-centric, self-serving manner	*Bazerman 2006*
Few perceived benefits for a state/region may partly explain residents' lack of public enthusiasm for expensive mitigation costs that may actually have greater benefits for a different region.	*Yarnal et al. 2003; O'Connor et al. 2002*
When global warming victims are not readily identified (particularly by those living in as yet unaffected regions, which may also be the source of emissions), it is not easy to see who benefits from mitigation policies and actions; notions of 'insiders' and 'outsiders' may encourage self-interest over support for a greater good.	*Baron 2006 Moser & Dilling 2004*
People are often unsure about the impacts and costs of individual climate change mitigation actions and/or see alternatives to 'life as usual' as too costly to them.	*Baron 2006*
Despite claims of wanting to leave a better world for future generations, people apply sharp discounts to future costs or benefits relative to experiencing them immediately. Climate change mitigation actions are seen as unattractive when they require immediate sacrifices in consumption, which are compensated by heavily discounted and highly uncertain benefits occuring far into the future.	*Bazerman 2006; Weber 2006; Moser & Dilling 2004*
Inexpensive, readily implemented, financially attractive legislation and personal mitigation measures receive higher levels of support.	*Yarnal et al. 2003; Dietz et al. 2007*
American citizens seem more supportive of climate change mitigation programs that impose costs on some abstraction like 'companies' or 'power plants' (e.g. legal controls on greenhouse emissions) than on individual citizens (e.g. requiring out-of-pocket expenditures).	*Sunstein 2007*
Assessing harm	
Positive illusions lead people to conclude that a problem (in this case climate change) does not exist or is not severe enough to merit action (the Optimism Bias).	*Bazerman 2006*
People often try to maintain status quo and refuse to accept harm, even if acting could bring greater good.	*Baron 2006; Bazerman 2006*
The Availability Heuristic – People are reticent to invest in preventing a problem like climate change that they have not personally experienced or witnessed through vivid data.	*Sunstein 2007; Bazerman 2006; Weber 2006*
Few Americans believe they have had personal experience with climate change (despite extreme events like Hurricane Katrina) and therefore have a low sense of personal (or immediate) harm.	*Sunstein 2007*
People can use inaccurate assessments of the likelihood of climate change bringing harm, or sometimes do not assign any probability. In these cases, strong emotions about outcomes have a greater effect than the likelihood of something occurring, particularly in the case of hope (e.g. gambling – vivid images of good outcomes crowd out consideration of probabilities).	*Sunstein 2007*

some time. He (and others) sees the lack of more definitive responses to climate change resulting from the collective effects of several cognitive patterns of decision-making [Table 4]. For example, they found that support for climate change mitigation and action is often linked to the extent that people see more benefits than costs from action for themselves and/or their localities, and they may have less concern about costs imposed on entities other than individuals (e.g. corporations) [Table 4]. People's assessment of the threat of climate change was also linked to their support (or not) of climate change mitigation [Table 4]. Positive illusions about the potential for harm from climate change and not having direct (and/or recent, vivid) experience of climate change effects can be powerful deterrents of support for mitigation policies and/or personal mitigation actions.

People's sense of responsibility to take positive, mitigative actions may also be influenced by their perceptions of what decision-makers are doing. Moser and Dilling (2004) suggest people are less concerned about climate change if they believe it is being 'handled', which can contribute to a 'see-sawing' of perceived urgency and the need to take personal action. Furthermore, Lorenzoni *et al.* (2007) found that public perceptions of limited political action by local, national and international governments, and business and industry; could constrain people's motivation to make behavioural changes.

Psychological, social psychological, and sociological research has been used to better understand how the particular characteristics of climate change, people's mental processes, and their social experiences interact to influence their views of and/or positions on climate change. Much of this research is focused on how the salience of climate change is reduced, which keeps many people from supporting mitigation policies and seeing it as a 'problem' warranting their personal, immediate response. These factors include the time delayed, abstract nature of climate change risks (e.g. a 'creeping environmental problem'), which make it difficult for a wide range of people to understand it. Many people also lack direct experience of climate change impacts, and often see it as distant in space and time. Many people seek to maintain the 'status quo', refuse to accept harm, and/or allow vivid images of good outcomes to suppress consideration of the probability of negative impacts. Support for climate change mitigation policies and personal action has been linked to the perceived convenience of and personal benefits from such initiatives, as well as to trust in government and science providers.

3.2.1.3 Sociological factors – social and cultural identities and experiences

The social science climate change research includes consideration of how people's background and experiences within society inform their views about climate change. O'Connor *et al.* (2002) found a range of social identities and experiences were likely to lead to increased support for climate change mitigation, including:

- having little experience with and/or anxiety about possible effects of mitigation actions on jobs;
- only being indirectly influenced by political affiliation (e.g. the Democratic Party); and
- having higher trust in institutions (e.g. greater trust in environmental scientists, less in industry) – this factor was most significant, particularly where people had less/low knowledge about climate change issues.

A number of researchers have considered how climate change beliefs differ among social/cultural groupings. A common distinction made is between that of experts and lay audiences. There have been studies examining differences in risk perceptions between and within expert/scientific communities and laypeople (see Botterill & Mazur 2004) generally, as well as on climate change in particular (Dessai *et al.* 2007; Stedman 2004; Lazo *et al.* 2000). Generally, it has been observed that experts tend to narrowly define risks using the dimensions of probabilities and severity of consequences, while laypeople's perceptions and interpretations of risk are based on a wider range of factors (e.g. scientific and technical descriptions of threat, psychological and social factors, such as personal experience, affect and emotion, imagery, trust, values, and worldviews (Dessai *et al.* 2007; Slovic 1999).

Dietz's *et al.* (2007) found that professionals tended to espouse definitions of environmental problems in a way that was consistent with their organisations' worldviews. Lazo *et al.* (2000) examined expert and layperson perceptions of the risks to ecosystems from climate change. They found that:

- laypeople perceived greater risks to ecosystems than did experts; and risks from global climate change (GCC) to be moderately worse than non-GCC risks; laypeople had greater uncertainty about GCC processes, which might have contributed to their presumption of catastrophic impacts;
- experts saw climate change risks as less controllable and less understandable compared to laypeople; and were also more accepting of risks from GCC – suggesting that laypeople think experts understand GCC risks to ecosystems and therefore while the risks are significant they are also manageable;

- laypeople maybe overly optimistic about policy options if they think GCC risks are known and controllable – a position suggesting the necessity only for modest sacrifices to protect ecosystems (and the converse); and
- experts were more likely to support 'cautiously aggressive' policy options, particularly those to reduce uncertainty about impacts and because they saw GCC as less controllable compared to laypersons' views (Lazo *et al*. 2000).

Langford (2002) examined existential anxieties as a means to better understand the different ways people respond to climate change, focusing in particular on the cognitive heuristic of biased assimilation and the influence of the media. In this context, people often selectively collect or evaluate new information that supports their previously held beliefs. In relation to climate change (and other, challenging environmental issues), people's opinions and views can be polarised, and based on confusing information and uncertainty, which can be heightened by misrepresentation of the issues in the media. Langford (2002) identified four main positions people adopted in relation to the importance and impact of climate change [Figure 3]:

- ***Denial*** (there is no problem, it doesn't concern me): high individualistic and/or hierarchist tendencies, view of self as reasonable/rational and open to new information, climate change information useful but questioned reliability, lack of personal responsibility in others explains inherent uncertainty in world, scientific uncertainty around climate change was divisive.
- ***Disinterest*** (there is a problem – but it isn't my problem): not concerned at present, fatalistic view on life (life beyond their control), anger at global capitalism, connectedness only in terms of being victims of impersonal economic and political forces, change only results through chance events.
- ***Doubt*** (environmentalists predicted catastrophe in the 1970s and 1980s – it didn't happen – why should we believe them now): do not believe in human impacts but feel issue is important, use feeling/intuition more than logic/rationalisation, open about their uncertainty about whether humans can change nature, need a balance between humans and environment, external locus of control to effect change;
- ***Engagement – willing*** (there is a problem, I would like to do something, but): high levels of concern and information gathering, more affective than cognitive responses, the ''good guys can win'', fear of uncertainty drained some motivation to act; and
- ***Engagement – keen*** (there is a problem, I am doing what I can): less judgemental of people, some crusader element, linked human actions and environmental impacts, anxious about uncertainty but can be addressed through commitment, effort, and education.

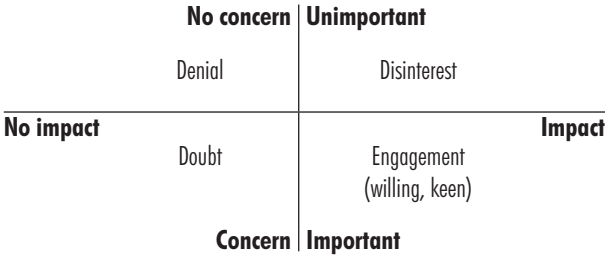


Figure 3. Different climate change positions. Source: Langford 2002

Leiserowitz (2005) identified three distinct 'interpretive communities' in relation to climate change [Table 5]. These interpretive communities are defined as groups of individuals who share mutually compatible risk perceptions, affective imagery, cultural worldviews, and socio-demographic characteristics. As noted earlier, 'dangerous' climate change continues to be contested by these interpretive communities, as well as by scientists, special interest groups, and political elites (Leiserowitz 2005; Stedman 2004).

People's views and actions relating to climate change are also influenced by their positions and experiences within society. People have numerous and dynamic interactions with other individuals, groups, organisations, and modern institutions (e.g. the media and governments). People are exposed to and/or are affiliated with different 'interpretive communities', which can be distinguished in a number of ways (e.g. expert/scientific communities versus the lay public) and whose views about the threat of climate change and the need for action run along a spectrum – with low risk perceptions at one end, high risk perceptions at the other, and a range of positions in between relating to the perceived salience of climate change and the need for (government, personal) action.

3.2.1.4 Sociological factors – communication, media and politics

Institutions, such as the Western media and governments, are key influences in climate change dialogues. The media is a key source of information on climate change, framing climate change issues using numerous affective images that highlight particular biophysical and political characteristics of the climate change phenomenon (Langford 2002). In addition, the media's predilection for reporting some risk stories more than others (often those eliciting higher risk perceptions) can itself influence public opinion (Palfreman 2006).

Table 5. Climate change interpretive communities in the United States. Source: Leiserowitz 2005

Position	Reasons	Predominate characteristics
Naysayers Low risk perceptions of climate change	Global warming is natural Its effects are exaggerated/hyped up The science of climate change is doubtful Deny the problem outright Assume conspiracy theories; and/or Deny the influence of human activities on phenomenon like weather/climate	White males Republican, politically conservative (pro-hierarchism, anti-environmental) Very religious Distrustful of institutions Politically active: more likely to vote and have strong representation in national government and allies in the private sector
Alarmists High risk perceptions of climate change	Climate change impacts will be extreme Any degree of further human interference will have catastrophic consequences	Pro-egalitarian and hold anti-individualist views and anti-hierarchist views Politically liberal, strongly supportive of government mitigation policies More likely to have taken personal action to reduce emissions
Others Moderate risk of climate change	Global climate change confused or conflated with ozone depletion	

Palfreman (2006) compared the media coverage of nuclear issues and global climate change. He noted classic 'dread' elements of nuclear power that generate high risk perceptions (e.g. potentially catastrophic events, lack of control, dread of effects of radiation). We have already seen that global warming lacks many of those characteristics. Furthermore, many global warming stories rarely focus on culprits or victims, and because much of modern life depends on fossil fuels, the public can be seen as both culprit and victim (Palfreman 2006). The American public's denial of the personal relevance of global warming is thought to be a result of the American media's reporting of climate change impacts as occurring in distant places and using images of impacts that are distant from the average American's way of life (Lorenzoni *et al.* 2006; Palfreman 2006).

There is also concern that the media and other numerous public sources of information on climate change are adding to public confusion and unrest. The climate change/global warming debate is often oversimplified and presented as polarised; the degree of disagreement is exaggerated; and overwhelming or frightening images are used – all of which can reinforce public uncertainty, scepticism, anxiety, denial and/or confusion over causes and solutions (Palfreman 2006; McDonald *et al.* 2006; Moser & Dilling 2004; Dietz *et al.* 2007; Langford 2002). Palfreman (2006) asserts that part of the problem is due to reporters not being better informed about climate change, and notes that inadequate science reporting can lead to the communication of scientific errors, predominance of human-interest stories rather than scientific content, and rigid adherence to the notion of 'balanced' coverage (which actually exaggerates the degree of disagreement).

Similar to the ideas on the social amplification of risk [see Appendix 3], Power *et al.* (2007) believe that the media, political interest, and some experiential forces played a key role in the Australian public reaching a 'tipping point' in their views on climate change between October and November 2006. They tracked the media interest in climate change issues, finding a steady increase in articles in three major metropolitan newspapers after 2003 referring to 'climate change', and a 235% increase between 2005 and 2006. Between July 2006 and May 2007, climate change articles ranked second highest in frequency. This media interest would be linked to political interest. Of the number of 'questions without notice' referring to climate change in Federal Parliament, 65% of them occurred after October 2006. Other key events were the releases of Al Gore's documentary (September 2006), the Stern Report (late October 2006), and prominent individuals voicing their concern (e.g. Tim Flannery). Power *et al.* (2007) also suggest that by October 2006, many Australians would have been directly affected by severe drought, noticed the record warm spring temperatures and bushfires, and been under some kind of water restrictions. Climate change was particularly salient for many people because (accurately or otherwise) the key message was, 'this drought is climate change' (Power *et al.* 2007).

3.2.1.5 Sociological factors – governance and citizens

A number of studies have examined the action of government decision-makers and sought to make links to climate risk perceptions and actions of individuals. As noted previously, these works seek to explain the lack of definitive action – by individuals and governments – to ameliorate the deleterious (current or future) impacts of climate change.

Baron (2006) suggests that global warming may

be receiving insufficient attention in the US because it lacks specific legislative infrastructure (e.g. such as the Endangered Species Act). He also notes that the resistance to more definitive action may also be due to the perceptions that mitigation policies will generate more benefits outside than inside the United States. The Bush Administration's stance on climate change is thought to be one factor influencing the fact that a greater proportion of Americans are sceptical about global warming than are citizens in Britain (Lorenzoni *et al*. 2006). Aware of the affective power of labels, the Bush Administration is purported to have instructed its departments and agencies to use the term, 'climate change' instead of 'global warming', because they believe the former term is more neutral, carrying fewer negative or scary associations (Weber 2006).

Moser and Dilling (2004: 35, 44) considered a number of organisational and political factors existing on multiple levels that contribute to the lack of international public (and policy) immediacy and urgency around climate change, including:

- time lags between the emission of heat-trapping gases and its subsequent impacts on climate, which make the connection between actions taken today and their future effects on climate difficult to perceive – inertia builds, and can lend stability to a system, but time lags create obstacles to preventing a chronic environmental problem from becoming a crisis;
- separations between cause and effect or inequities in distribution of benefits and costs (e.g. political-economic separation in space between powerful, unaffected decision-makers and those most negatively affected by climate change);
- the tendency for political attention to issues (e.g. climate change) to wax and wane through numerous 'issue cycles', with people distracted by competing demands on their attention;
- structural barriers in how information is collected, processed and used (e.g. organisational silos without definitive responsibility for making 'good' climate decisions assigned to a particular groups or individuals); and
- dysfunctional incentives (e.g. when no one thinks they are in charge, and just do their job).

Lorenzoni *et al*. (2007) were interested in why (in the US and UK) the relatively widespread awareness of climate change and general agreement about personal, social and moral responsibilities for addressing climate change has translated into only a minority of the public taking actions to reduce their energy consumption. In addition to individuals' cognitive barriers, they found a range of social-scale barriers to widespread behaviour change, including:

- lack of locally-relevant information, inaccessible formats, and untrusted sources;
- lack of enabling infrastructures and mechanisms (e.g. affordable, convenient public transport);
- social norms and expectations requiring carbon-dependent lifestyles (e.g. preferences for high standards of living); and
- interdependency of physical infrastructures and social institutions contributing to restriction of innovation in environmentally-friendly products, services and habits (Lorenzoni *et al*. 2007).

Political systems also influence (and can be influenced by) widespread social trends in their respective populations. Social researchers have found various organisational and political factors constraining more definitive shifts towards larger-scale mitigation actions. These include governments' strong stances against and/or equivocal positions in relation to the threats of climate change, low salience of climate change contributing to political and bureaucratic inertia, lack of enabling infrastructure and incentives, lack of quality and credible information provision, and social norms and expectations favouring carbon-dependent lifestyles.

People's responses to climate change are also informed by institutions such as the media, which often oversimplifies, polarises, and exaggerates levels of disagreement about climate change and its impacts. This treatment of climate change can generate further public uncertainty, scepticism, anxiety, denial and/or confusion. At the same time, some social scientists believe that the media, political interests and some experiential forces have converged to play a key role in increasing levels of awareness and concern among the Australian public about climate change.

4. Responding to a changing climate (landholders and farmers)

The process of change is fundamental to mitigating and adapting to climate variability. Policy prescriptions are often, in effect, asking a range of actors to change their practices. There are particular factors (external/internal) influencing (in a positive – enabling – way, in a negative – constraining – way) how farmers/landholders respond to change generally, and climate change/variability in particular. Consequently, there will also be varying capacities among these participants to adapt. Several areas of theory shed light on adaptations to climate change, including psychology and rural sociology.

4.1 Farmers/landholders' views on climate risks

Agriculture always involves some degree of risk (Geurin & Geurin 1994), and in south-eastern Australia farmers (as an occupational group) and other rural landholders and community members are likely to be highly exposed to the direct impacts of climate change. Consequently, it is valuable to consider what similarities and differences might exist in the climate risk perceptions and responses of rural communities and amongst farmers and landholders. Improved understanding of climate risk perceptions and how those perceptions influence behaviour is an integral component of developing effective rural policies and programs (Krogmann *et al.* 2001; Shrapnel & Davie 2000; Pannell 2003).

4.1.1 Believing and/or understanding climate change

Some international research suggests there is mixed awareness and understanding of climate change among farmers and rural landholders. In the United Kingdom, 81% of farmers surveyed believe global climate is changing; 70% believe changes to their practices can offer business benefits; 60% said they were already affected by climate change, and 70% expect to be affected in the next ten years (Farming Futures 2007).

A Canadian (Ontario) study of responses to climate risk in agriculture looked at farmers' understanding and awareness of climate change. Reid *et al.* (2007: 630) found that farmers were generally aware of existing climate related risks affecting their operations and generally aware of or unconcerned about potential effects of climate change, which was attributed to conventional descriptions of climate change (e.g. small increases in average temperatures over several decades). Reid *et al.* (2007) also found that the term 'weather' was one of several future risks identified, and only two out of 26 farmers made specific reference to 'climate change'. When asked specifically about future climate risks and opportunities, farmers did not specifically mention 'climate change', but did identify phenomena that suggested they had some awareness of climate change related issues (e.g. opportunities to grow higher heat varieties; negative risk of longer heat waves). When asked specifically about climate change:

- 62% of respondents said they thought it was a long-term warming trend ('global warming', 'greenhouse effect');
- 17% associated 'climate change' with a change in the variability and extremes of the weather, including more frequent droughts, and these farmers were most concerned about climate change; and
- only 21% of farmers were entirely sceptical about human-induced climate change – perceiving the changes in climate to be 'natural' (Reid *et al.* 2007: 630).

In Africa, large numbers of farmers already sense a hotter climate (rise in average temperatures) and shorter-less predictable rainfall events (decreased rain levels and changed timing of rains) (de Wit 2006). They tend to update their expectations of climate in response to unusual weather patterns by looking back at recent weather patterns.

Austen *et al.* (2002) undertook a survey of 62 producers in the perennial pasture zone of south-eastern Australia to gain an understanding of farmer attitudes toward climate variability, the use of weather and seasonal climate forecasts on farms and how climatic variability affects farm management. They found that climate was universally recognised as impacting on productivity, but most farmers had only a moderate level of understanding of key climate drivers relevant to their enterprises. McDonald *et al.* (2006) made a similar conclusion from their study of landholder views about climate change in North Central Victoria, Australia. McDonald *et al.* (2006) also found there was confusion amongst landholders about the different components of climate change and types of impacts – many considered the potential influence on rainfall rather than on other climate/weather events. The dominant beliefs ranged from 'I don't believe it', to 'I'm waiting to see more proof before believing it', with a few in the category of 'I believe it will/is already happening'. Interviewees in this study also thought that public dialogue about climate change was highly politicised. Most interviewees were also confident in their ability to adapt to changes – given that they had changed their practices in the past in response to changed conditions – and believed technology would help overcome

future climate challenges.

In a qualitative study of climate risk perceptions in rural (primarily agricultural/farming) industries in Australia, Milne *et al.* (2008) found that:

- perceptions of climate change were highly variable: while most people were open to the idea that climate change is a reality, many were still forming their ideas about it;
- there was considerable uncertainty around whether the extended current drought was a symptom of climate change with most questioning the link (e.g. drought was part of a natural cycle rather than due to anthropogenic change), but most respondents saw the drought as 'normal';
- respondents' most optimistic thinking was that the drought would break and things would return to 'normal';
- more respondents in the dry-land communities than the irrigated areas thought climate change was caused by human-induced emissions of greenhouse gases;
- the most frequent physical changes perceived was a continuation of drier and warmer conditions, a shift in seasons, and greater variability in the weather; and
- some respondents felt bombarded by a plethora of conflicting information on climate change.

4.1.2 Factors influencing farmers'/ landholders' (climate) risk perceptions

What might be affecting the way these farmers and rural communities are seeing climate change? Some of the studies reviewed below are focused on a range of risks faced by farmers, while others have a specific focus on their perceptions of climate risks and climate change risks. Not surprisingly, this research suggests that – similar to the studies of the general public's views on and responses to climate change – the risk perceptions and climate risk perceptions of people in rural areas and agricultural industries are influenced by multiple psychological, social and institutional factors. Consequently, farmers have varying levels of comfort managing risk generally, as well as certain kinds of specific risk.

McCarthy and Thompson (2007) found that farmers' general risk perceptions were influenced by their individual experiences, world-views, and those perceptions varied over time given a range of environmental (climatic) conditions, market conditions and personal circumstances. They assert that farming styles influenced farmers' degree of confidence in taking and managing general risks, with more farmers willing to take risks under particular conditions (57%), than those who were highly confident (28.7%) or avoided taking risks altogether (12.3%) [Table 6].

Table 6. Farming styles and risk preferences. Source: McCarthy & Thompson 2007

Farming styles	Percentage of sample
Risk aware, confident risk takers	4.0%
Confident risk managers prepared to take risks to get ahead	24.7%
Confident risk managers and risk-takers, when business is secure	17.8%
Guarded risk managers	19.6%
Cautious risk takers	20.1%
Risk avoiders	12.3%

Flaten *et al.* (2004) also studied risk perceptions and responses of conventional and organic dairy farmers in Norway. While they did not develop a specific typology as such (see McCarthy & Thompson 2006 above, Table 6), they did conclude that most farmers were risk averse, and varied in their willingness to take risks. They also considered farmers' responses to different types of risks. Conventional and organic dairy farmers both saw institutional risks as the primary source of risk. The conventional farmers were more concerned about costs of purchased inputs and animal welfare policies, while the organic dairy farmers gave more weight to institutional risks affecting their production systems (organic farming payments, price premiums, and organics regulations) (Flaten *et al.* 2004).

Harwood *et al.* (1999 as cited in Flaten *et al.* 2004: 2–3) found that while views varied, US farmers were most concerned about price risks, production risks, and changes in laws and regulations affecting agriculture. They determined that beef producers in Texas and Nebraska were most concerned about severe droughts, while New Zealand dairy farmers saw rainfall variability as the greatest risk.

McCarthy and Thompson (2007) also looked at farmers' responses to different risks. Their Australian study found that farmers were generally least comfortable with three kinds of risks: commodity price downturns (39% *not comfortable*), climate change (30% *not comfortable*), and injury/illness (24% *not comfortable*). They also found that farmers were most comfortable with the risks of family relationship breakdown (57% *fairly comfortable*, 26% *very comfortable*), fire/frost/floods (65% *fairly comfortable*, 21% *very comfortable*), and some farmers indicated their relative comfortableness dealing with climate change (49% *fairly comfortable*, 18% *very comfortable*).

In another Australian study (Victoria), Price *et al.* (2006) found that the most important climate risks for grain growers were a lack of rain, timing of the growing season rainfall, poor spring finish (rain or temperature) and frost. The most important issues when conducting paddock plans were economic

return, paddock rotation, input costs and minimising financial risk. They found that target yield was more important for those growers who had heard of climate decision support tools.

Why might climate change generate a different (and sometimes lower) sense of urgency than other farm risks? Reid *et al.* (2007) attributed Canadian farmers' relative indifference to climate change to the very qualities of the phenomenon itself – that is, climate change tends to be viewed as a long-term trend, something that is too far into the future to experience directly and therefore a focus on more immediate issues is common. This finding is consistent with findings from the studies of climate risk perceptions among the general public (see Section 3.2.1 – O'Connor *et al.* 2002; Weber 2006; Leiserowitz 2005; Lorenzoni *et al.* 2006; Moser & Dilling 2004). Both Reid *et al.* (2007) and McDonald *et al.* (2006) attributed some of the confusion and general scepticism about climate change in rural areas in part at least, to the following factors:

- confusion resulting from conflicting, contradictory information in the media about the existence and impacts of climate change;
- those better informed about climate change tended to be more proactive about seeking information; and
- some information sources were trusted – and therefore used more than others (e.g. information sources contradicting landholders' views/experiences and/or not accounting for other land management challenges were generally disregarded).

International research suggests that the level of awareness and understanding of climate change varies amongst farmers and rural landholders. In contrast to recent Australian opinion polls suggesting high levels of awareness and concern about climate change amongst the wider public, several case studies in agriculturally-dependent communities in NSW and Victoria have identified highly variable levels of awareness and understanding of climate change. While many in these communities are open to the idea of climate change, considerable uncertainty and confusion exists about the concept. A substantial proportion of these research participants were unable to clearly distinguish between climate risks more generally (e.g. drought, variable climate) and 'climate change' in particular. Participants frequently saw drought as part of the 'natural' climate cycle, which would (hopefully) break soon and there would be a return to more normal (wetter) conditions. Similar to studies of the general public, research on farmers' climate change views identifies multiple psychological, social and institutional influences. These include individual experiences and situations, worldviews, environmental and market conditions, degrees of comfort with different kinds of risk, the abstract and distant nature of climate change, and access to particular sources of climate change information.

4.2 Climate change adaptation – a form of farm risk management

As noted above, agriculture is a risky business. Landholders have to continually adjust their activities in response to myriad risks and changes, such as production, price or market, financial, institutional, and human or personal risks. Climate risk is one type, albeit a key source, of risk to which farmers will have a range of responses. Landholders employ a range of strategies to help them manage those risks – typically by averting, diversifying, and/or insuring against the risk (George *et al.* 2005; Crockford 1986; Harding 1998). Their strategies help them – to a greater or lesser degree – 'adapt' to a range of conditions and circumstances. Hence farm risk management can be seen as a form of adaptation. Yet, it is worth noting that at the farm-level, climate risks might not be so readily considered in isolation of the myriad risks/stressors that farmers respond to (Wehbe *et al.* 2006; Reid *et al.* 2007; Steffan *et al.* 2006; McCarthy & Thompson 2007; Milne *et al.* 2008).

Nonetheless, some examples of management or adaptation to climate risks have been identified in developing and developed countries. These include land and resource management practices (changing production strategies and techniques), financial management strategies (use of insurance, off-farm investments), climate forecasting and planning (use of seasonal climate forecasting), capacity building, and participating in networks (see Phillips *et al.* 2005; Wehbe *et al.* 2006; Burton & Lim 2005; Leith 2006). In Canada, Reid *et al.* (2007) suggested that responses could be classified according to the stage of the hazard (pre, during and post event) [Table 7].

Milne *et al.* (2008) identified a range of farm-level climate risk management strategies (both at the production and business levels) [Appendix 5], and the most frequently mentioned strategic actions undertaken by farming representatives in south-east Australia included:

- ***water-use efficiency*** (to manage climate risk and low water allocations) – emphasis on efficient water systems in irrigation areas and farming techniques to retain soil moisture in dryland areas (e.g. direct drilling, tillage retention, soil moisture monitoring, micro-sprinklers and dripper systems, taking some areas out of production);

Table 7. Farm-level adaptations to climate risks (in Canada). Source: Reid et al. 2007: 627–628.

Timing of management		Adaptations
Pre-risk (anticipatory)	Risk reduction	Diversification of farm enterprise (e.g. adding another farm enterprise, custom work)
		Diversification of cropping system (e.g. change crop hybrids, plant range of corn varieties with different heat tolerances)
		Soil conditioning (e.g. crop rotation schedules, applying manure to fields, no-till)
		Technological innovations (e.g. investing in larger equipment to increase efficiency, use of biotechnology)
		Improved drainage (e.g. add drainage tiles)
		Off-farm income
		Changed timing of farm practices (e.g. breeding cattle in spring to avoid hot weather)
Pre-risk or during risk	Risk hedging	Carrying feed reserves (e.g. maintain hay inventory, increase storage capacity)
		Alternative uses for poor crops (e.g. feeding poor quality cash crops, pasture cattle on wet hay fields, corn silage)
		Use of pesticides for insect infestations
		Change timing of operations (e.g. plant seed to moisture, wait for dry to plant, replant if seedlings drown, harvest crop according to weather)
		Livestock husbandry responses to hot summer weather (e.g. overbreed pigs to compensate for low conception rate in heat, water down pigs in heat, run water on chicken barn to lower heat)
	Risk transfer	Participation in crop insurance Participation in government safety-net programs
Post-risk (reactive)	Risk mitigation	Purchase livestock feed when crop fails
		Engineer structures to prevent crop loss
		Stop growing sensitive crops
		Respond to growing season conditions the following year (e.g. planted lower heat unit corn after cool year, insured corn after poor year)
		Keeping livestock out of hot sun (e.g. building shelter, keeping animals in barn, add ventilating fans)

- ***diversification*** (reduce long term impacts from climate change and increase flexibility) – changes to production activities, off-farm investment (e.g. growing lower risk crops, selling fat lambs, part-time work, expanding into a different business/market); and
- ***exiting the land and succession*** (in response to long term, continuous drought and declining terms of trade and reaching a viability 'threshold').

Climate risks are only one of the myriad risks for which farmers and landholders develop some kind of response strategy. While climate risk management (or adaptation) strategies are not always easily distinguished from other risk management actions that farmers and rural landholders take, some examples have been identified. These actions include making changes to land and resource management practices, financial management approaches, climate forecasting and planning, participation in information networks and building skill and knowledge bases.

4.3 Determinants of adaptation to climate change

In addition to the uncertainty over exactly how climate change impacts will manifest (and with what kinds of variations), it is not yet clear to what extent different agricultural sectors and communities can keep pace with unprecedented climatic change. What seems certain is that there will be differential capacities of regions, industry sectors, communities, and individuals to adapt (see Niemeyer *et al.* 2005; Grothmann & Patt 2005; Adger 2000; Burton & Lim 2005). As discussed in Section 2, there is considerable and growing interest in how to improve adaptation to climate change by identifying those factors enabling or driving effective industry, community and individual responses, as well as mitigating the obstacles to appropriate adaptations.

4.3.1 Converging theories – rural sociology and climate change adaptation

Understanding human behaviour and its social and institutional context is a key to understanding and managing change processes in primary and rural industries (McGoodwin 2001). In the last twenty years, social scientists interested in increasing the sustainability of agriculture and natural resource

management have identified a range of factors and conditions that inform whether and how land managers modify their practices to comply with new and/or different conditions and requirements (e.g. taking up sustainable practices, new technologies). Work in this area highlights that people have different abilities and inclinations to respond (i.e. adaptive capacities) (Pannell *et al.* 2006; Douthwaite *et al.* 2001; Cary *et al.* 2002; Nelson *et al.* 2006).

There are numerous research approaches to climate change adaptation in agriculture [see Appendix 6], and they vary in the degree to which they emphasise:

- specification of climate effects/impacts;
- system and institutional (macro) processes versus individual, farm-level and community (micro) processes;
- hazards and extreme and/or dangerous events and the responses of systems and people;
- technological (as opposed to non-technical) adaptations to climate change and their dissemination/uptake;
- climate as a source of risk and risk perceptions; and
- varying decision-making actions of individuals and their capacities for adaptation in the face of change.

Figure 1 provides a synthesis of two key frameworks that have been used by social scientists to understand the influences on people's adaptations to changes in their environment. These researchers have been interested in increasing the uptake (by landholders) of practices that are meant to improve the sustainability of agriculture (or other primary industries) (Cary *et al.* 2002; Pannell *et al.* 2006; Pickworth *et al.* 2007; Nelson *et al.* 2006) and/or ameliorate negative impacts or create opportunities from climate change (Reid *et al.* 2007). Figure 1 shows that landholders operate their (commercial and non-commercial) properties in a complex and dynamic environment. People have different abilities and inclinations to respond to a range of conditions and stimuli that occur at different scales, and which drive or constrain their capacity to adapt. These factors may overlap or work in conjunction to exacerbate constraints to or enable adaptation. Those conditions and stimuli include:

- ***factors particular to individuals:*** a range of personal characteristics, such as their value and belief systems, attitudes and perceptions, personalities, motivations, goals, and culture;
- ***a range of resources:*** these include different forms of 'capital': social, human, financial, physical, natural) in their relatively immediate environment that people (consciously and unconsciously) draw on, which also inform their decisions about whether they can make certain changes to their practices;
- ***the nature of the practice:*** essentially the feasibility and benefits of practices that may be or has been taken up in response to some kind of change; and
- ***the broader operating environment:*** factors generally considered to be beyond the direct control of a landholder, such as economic conditions and pressures; government policies, legislation, programs and priorities; public pressures; and environmental conditions (e.g. climate change).

Further examples of drivers and constraints derived from the literature are listed in Appendix 1.

Figure 1 also illustrates the different levels and scale of activities to consider, such as individual and family decision-making, the interaction of those individual and family decision-making units with other landholders in their local or regional rural communities, the aggregate of actions within a regional agricultural system, and actions occurring at the regional level or the wider operating environment.

4.3.1.1 Landholder characteristics

Grothmann and Patt (2005) believe that the main determinants of climate change adaptation are due to variable cognitive processes in individuals. They noted that some people show higher degrees of adaptive behaviour while others do not, because of their:

- ***risk appraisal*** – people consider a threat's probability and potential to damage the things they value, and includes 'perceived probability' (a person's expectancy about being exposed to threat) and 'perceived severity' (how harmful they believe the consequences will be for the things they value); and
- ***adaptation appraisal*** – people evaluate their ability to avert being harmed by the threat – only if their specific threshold of threat/risk appraisal is exceeded; this 'perceived adaptation efficacy' (would actions effectively protect them from threat), 'perceived self efficacy' (do they have the ability to perform/carry out those actions), and 'perceived adaptive costs' (what does it cost to take action).

Grothmann and Patt (2005) do acknowledge the influence of sociology and institutional factors on climate change adaptation. And as will be discussed further in Section 4.3.1.2 below, a person's ability to adapt is not merely a function of what they think they can do, but also what resources are actually available for them to draw on to make those adaptations.

Grothmann and Patt (2005) also considered the effects of the optimism bias, availability heuristic, personal experience, and social discourses on risk appraisals. They found that Zimbabwean farmers were not making changes to their practices

in response to climate change information and lacked the intention to adapt, because of their low risk perceptions (which diverged from formal risk assessments) and their unwillingness to believe that their actions could protect them from harm (low perceived adaptive capacity).

The study of farmers by Phillips *et al* (2005) in the Hudson Valley (USA) also draws on risk perception theory (heuristics and emotion and affect). These authors mapped the mental models of distributions of important extreme weather events and their relationship to adaptive strategies to assess farming system resilience to climate extremes. Phillips *et al*. (2005) suggested that over weighting of recent events by farmers when building mental models might be providing a positive bias that favours adaptive actions. For example, thriving farms were innovative and adaptive – with 19% of farmers noting an increasing trend in rainfall extremes and a higher percentage acting on that trend and adopting strategies to mediate against the negative effects.

Based on a study in the rangelands of south-east Queensland, Leith (2006) also emphasised the importance of farmers' personal decision-making processes. Leith (2006) noted that graziers' interpretations of seasonal conditions were fundamental to determining what actions they undertook. Graziers tended not to base their decisions on formal records/processes, but more on their experience and knowledge of their country and of previous seasons. Their knowledge of climate history was often described not just in relation to rainfall, but in terms of how they believed the countryside was responding to a variety of factors associated with a given season – with season and landscape often tied together in people's descriptions of climatic conditions. Graziers tended to use local signs and patterns to assess how a season was shaping up. Their ideas about what made for 'good management' or 'best practice' were dynamic.

The Optimism Bias [see Table 4] may have been shaping the response to climate change of many graziers in south-east Queensland. Leith (2006) found that these graziers recognised the need to prepare for drought, but then expressed the hopeful position that, as they had endured the worst the country had to offer, they would not see the likes of it again. This position was inconsistent with official probabilistic information provided or available to the graziers. These graziers did not appear to trust scientists' probabilities. Indeed, many wanted to verify those predictions with their own experience of seasonal conditions. Leith (2006) suggests that the graziers' desire to 'test' the 'accuracy' of forecasts was not just a matter of a lack of trust, but also their desire to be independent.

Milne *et al*. (2008) drew on behavioural theory to develop a model of (primarily) individuals' capacity to adapt to climate change. They asserted that:

- **people ascribe meaning to climate change** through the lens of their: risk perceptions (what is the likelihood of being exposed to climate change, and with what consequences), knowledge of the causes of climate change and options for action, and their environmental beliefs and values which guides their focus; and
- together these inform their **motivations** and **intention** to take some kind of adaptive action, which are most often in response to a perceived threat, a sense of a challenge, as well as feeling a moral obligation to act.

Milne *et al*. (2008) note that those actions are underpinned by an ability to act (adaptive capacity), which needs to be supported by a range of personal, social, financial, and institutional resources (e.g. time, money, persistence, self-efficacy, knowledge, education, networks, institutional support). The level of exposure of an individual or group to a risk and their sensitivity to its effects will be modified by their capacity to adapt. Adaptive capacity is the ability to carry out adaptations within the context of enabling and constraining factors in their operating environment, that come into play where people are forming their motivations/intention to act (Milne *et al*. 2008).

Milne *et al*. (2008) developed a typology of climate change beliefs and associated actions of managers of agriculturally-dependent businesses in rural Victoria and NSW [Table 8]. They found that small business managers believing in climate change and its impacts on agriculture were generally more likely to be planning or undertaking strategic action to address climate risk. However, in contrast with the research above (e.g. Grothmann & Patt 2005; McDonald *et al*. 2006; Reid *et al*. 2007), Milne *et al*. (2008) were more circumspect when making a causal link between belief in climate change and adaptations because;

- people's motivation and choice to adapt to climate change is also determined by a range of other values and attitudes relating to rural life, knowledge and awareness of available adaptation options, and particular skills (e.g. business professionalism);
- people will be managing for numerous risks simultaneously, including climate change and it can be difficult to distinguish whether changes people make are in relation to climate change, drought or other drivers; and
- there were cases where managers who believed in climate change were not taking action, while some managers who were sceptical about climate change had implemented some risk strategies.

4.3.1.2 Access to resources

Figure 1 shows that the capacity to change will relate to actors' access (perceived and actual) to an array of resources. These resources might include the condition of the natural assets on their property (e.g. access to water, soil condition, amount and health of remnant vegetation), social capital (e.g. their degree of connectedness to social and information networks like other landholders), human capital (e.g. required labour), financial capital (e.g. their income levels and the economic viability of their enterprise, etc.) and physical capital (e.g. farm equipment).

In addition to identifying a range of psychological factors, de Wit (2006) identified how farmers' access to a range of financial, physical, natural, informational resources functioned as barriers and drivers to climate change adaptation in African agriculture. They found that:

- ***barriers*** to adaptation included farmers' lack of credit/savings; lack of access to water and to appropriate seed; lack of security of property rights; lack of market access; in some cases lack of information about the weather or long-term climate change; and greater distances to markets; while
- ***drivers*** to climate change adaptation included – in addition to farmers perceiving climate change – farmers having more experience; receiving free extension services (particularly those focusing on crop and livestock production), which accommodate the most common ways farmers learn (by doing, copying from others, and with instruction); level of education and being head of a household; having larger farms and the capacity to address adaptation costs; and occupying land that was already marginal.

Milne *et al.* (2008) identified key social resources that help to drive climate change adaptation, including:

- access to professional networks and relationships – adaptation was enabled where respondents were linked to a widening network of advisors (e.g. accountants, suppliers, agricultural extension officers) and where good client and personal/social relationships were fostered; and
- leadership and vision – strong community and political leadership supportive of climate change adaptation was fundamental to maintaining communities' and individuals' hope and vision for the future, as well as encouraging uptake of community-scale opportunities (e.g. green energy initiatives).

Milne *et al.* (2008) also noted physical and economic factors that respondents believed were constraining climate risk management, including:

- farm-level infrastructure limitations such as water availability and allocations, permanent plantings, storage silos and farm machinery, as well as limitations of sectoral and regional infrastructure (e.g. irrigation systems, channel capacity and operation, difficulty in shifting horticulture infrastructure); and
- limited financial capacity at the farm level (e.g. significant investment required to undertake some risk management strategies, the need for a strong, economic base from which to manage impact of dry conditions), exacerbated by high input costs (fuel, wages, fertilisers, machinery) relative to broader economic conditions (e.g. low commodity prices, reduced market access, high land prices, narrow economic base of regional centres).

4.3.1.3 Characteristics of practice/source of risk

The design and delivery features of climate change adaptation practices will influence landholders' decisions to use them. Landholders will think about whether they have enough information about the risks of changing a particular practice or using a particular technology, and ask themselves and others, 'Will it work?', 'How will it benefit me/my business?', 'Are others doing it?', 'Can I trial it?', and/or 'How much do I trust the person/organisation'

Table 8. Links between climate change beliefs and risk management strategies. Source: Milne et al. 2008.

Beliefs	Action	Examples
Open to the idea that climate change is happening (35%)	Implementing strategic or long-term changes to their business	• Diversification (moves to other industries, moving into service provision) • Adopting R&D
Sceptical or uncertain that climate change is happening (15%)	Did have strategies in place	• Expansion &/or diversification of business • Short term risk management (selling stock, joining buying group)
Open to the idea that climate change is happening (24%)	Felt somewhat overwhelmed, saw as low priority	• Lack of clear ideas • Putting up with it or sell business • Respond to immediate issues
Sceptical or uncertain that climate change is happening (26%)	Few preparedness strategies	• Having crisis meetings • Surviving day-to-day

encouraging the change?' The attributes of prescribed practices intended to mitigate or provide some kind of adaptation to climate change are also informed by external factors, such as the rationale and resources of government and/or science agencies which underpin the design and delivery of those programs, activities, and information.

McDonald *et al.* (2006) found that landholders in Central Victoria:

- were concerned about what they perceived to be poor, inappropriate, inconsistent, and/or the contradictory tone and content of certain climate change communications, which increased their confusion and/or mistrust and could hamper farm-level uptake of adaptations (see also Leith 2006); however,
- the track record of past successful natural resource management (NRM) innovations, particularly those relevant to landholders' local situations which were delivered by credible, local people could drive adaptations; and
- incentives used in other NRM programs/initiatives and applied to climate change adaptation could also assist uptake.

4.3.1.4 Operating environment

The wider, operating environment of agriculture mediates landholders' choices about how – if at all – to respond to climate change. McDonald *et al.* (2006) found that certain aspects of farmers' social and institutional environment functioned as barriers to their adaptation to climate change, including:

- globalisation/open markets adding to the complexity and costs that farmers are unable to 'pass on' to purchasers of their products; and
- decline of some regional communities, and other uncertainties associated with farming that detract from its viability and appeal to successive generations.

Milne *et al.* (2008) note certain features of agriculture's regulatory and policy contexts, including rules relating to water planning and allocations (historical over-allocations, environmental flows, water trading) that were seen by study participants as both drivers and constraints mediating access to resources and entitlements. Milne *et al.* (2008) noted how these frameworks provide a structure of incentives and disincentives within which people weighed decisions about farm and business management.

The IPCC's analysis of the main barriers to climate change adaptation in Australia was applicable to several other sectors, including agriculture. These barriers were considered ''formidable'' and included:

- a lack of appropriate methods for undertaking (local/regional) area-wide integrated assessments of climate change impacts and adaptation (e.g. across water resources, coasts, agriculture and ecosystems);
- a lack of well-developed evaluation tools for assessing the effectiveness of climate change adaptations in local and regional areas;
- ongoing public scepticism about climate change science, scientific uncertainty in regional climate change projections, an overall lack of knowledge about how to promote adaptation, and few examples of risk-based methods of planned adaptation being applied; and
- poor linkages and coordination between different levels of government regarding adaptation policy, plans and requirements; a lack of stronger guidance and support from State/Territory jurisdictions to underpin local adaptations, particularly how adaptations could/should be accomplished and what resources are available to facilitate required capacity building (Hennessy *et al.* 2007: 525–6).

There will be variable capacities for and rates of adaptation to climate change in rural communities and among different types of landholders. Those interested in facilitating the widespread use of effective climate change adaptations can benefit from research (rural sociology and climate change adaptation research) which examines the range of complex factors which influence whether and how different landholders modify their practices. This body of work has identified a range of personal characteristics, access to a range of resources, the nature of the (recommended and/or selected) adaptations, and the broader operating environment.

To date, the following factors have been linked to climate change adaptations: (Personal characteristics) strong belief in climate change and its causes and threats, direct experience of climate change, high perceived benefits of adaptation, confidence in own ability to adapt, high trust in science, strong environmental values; (Resource access) higher education, greater professional experience, strong community leadership, social norms in favour of climate change action, economically viable farm businesses, larger farm sizes; (Characteristics of adaptive practices/programs) previous local success of NRM innovations, extension programs delivered by trusted/credible people, interactive/informal extension designs, appropriate incentives; (Operating environment) certain aspects of water planning and allocations, mass media, climate change impacts.

5. Adaptation to climate change – communication and engagement

In many cases climate change mitigation and adaptation require a range of actors to use ideas, practices and tools that may challenge the status quo, and do so in a context of great uncertainty. The considerable research already undertaken in the field of risk perceptions, adoption of natural resource management practices, and climate change adaptation offer a wealth of insights – namely how different climate change risks are viewed and how we might best engage and enable different audiences in mitigating and adapting to climate change.

5.1 Re-thinking risk communication

There is a substantive body of international work which argues that we need to re-think the way we communicate with the public about various technological, health, and environmental risks. This work covers a spectrum of topics that range from addressing the content and style of information transfer to redefining the entire process of who we 'communicate' with, how and for what reasons. Older models of risk communication[9] tended to be somewhat paternalistic and derisory. They defined the public as an essentially naïve audience and recommended 'one way' processes where increasing amounts of technical and scientific information be disseminated to the public in an effort to raise literacy levels, to counteract 'irrational' opinions and to build support for various policies and programs in the face of concern and/or opposition (Jones 2005; Gutteling & Kuttschreuter 2002; Sly 2000; Slovic 1999; Peters *et al.* 1997). These approaches are believed to have outlived their usefulness for modern risk contexts and may have even contributed to some contemporary societal conflicts over risk, particularly lowering confidence in experts, policy makers and government (Jones 2005; Parliamentary Office of Technology 2001).

The newer models of risk communication essentially re-construe notions of risk and risk perception by:

- emphasising the socially-constructed nature of 'risk' (and uncertainty)[10];
- valuing different forms of knowledge; and
- advocating for greater levels of meaningful public participation in risk assessment and management (Jones 2005; Lorenzoni *et al.* 2005; Petts & Leach 2000; Slovic 1999).

Most advocates of these models recognise the significant practical and ethical challenges to facilitating more and more inclusive and meaningful dialogues with the public about risk issues (Jones 2005; Marsh & Buckle 2001)[11]. The attitudes and capabilities of those responsible for/communicating about risk matters are just as important as those of their audience, and in many situations risk managers and scientists have neither the formal training nor role that is conducive to more effective engagement with the broader public (MORI 2000; Jones 2005). Designing and implementing more savvy risk communication and engagement approaches will be enabled by supportive agency cultures, sufficient motivation, and appropriate types and levels of resources to address skills shortages and training needs.[12]

5.2 Climate risk communication – capacity and design matter

Recently there has been growing interest in how we apply newer models of risk communication to most effectively engage a range of audiences about the specific risks associated with climate change. This work focuses on appropriate institutional structures and capacities required for influencing positive climate change actions, as well as on particular strategies for targeting and engaging different perspectives among the broader climate change audience.

The media's role in climate change communication has received considerable attention to date, primarily in regards to improving its capacity to build better public understanding of complex environmental phenomenon like climate change. Palfreman (2006) asserted that journalists need to expand their reporting on risk facts (physical dimensions of the problem) to better include how people feel about those risks and why. Similarly, Lorenzoni *et al.* (2005) felt that the media needs to focus more on long-term, consistent, and cross-cutting coverage rather than sensationalising the catastrophic potential of climate change. They felt that climate change reporting would need to provide better information about the 'messy' edges (uncertainty) around climate science and issues of scale. They also felt that the media could spend more time presenting the dominant scientific perspective about climate change, rather than over-emphasising competing arguments for the sake of presenting a 'balanced' story.

Consideration has also been given to the role that decision-makers play in climate change dialogues, and what kind of increased capacity is needed. Similar to his assessment of journalists' capacity, Palfreman (2006) focused on the need for policy makers to upgrade their risk assessment skills, ability to understand how people think about adverse events (risk perceptions), and

to effectively tell a story (risk communication). Others have cited a need for greater understanding and empathy among decision-makers in order to create and maintain the momentum required for widespread and continued climate change mitigation action on the part of individuals, organisations, industries and political entities. For example, the UK Department of Environment, Food and Rural Affairs and the University of Liverpool entered into cooperative arrangement to find new ways to improve – on the one hand policy makers' knowledge of more 'socially aware' approaches to risk, and on the other social scientists' understanding of the structural and political barriers to achieving 'ideal' models of risk governance (Jones 2005). Another example of recommendations to improve climate change policy dialogues is the recent initiative hosted by the University of Melbourne (2008). A Roundtable was held on the implications of climate change, which identified a range of priorities for climate change policy makers [see Box 1].

Box 1. Roundtable on the Implications of Climate Change – Priorities for shifting the Australian climate change debate:

- No single solutions – work is needed by a range of actors across sectors and across disciplines;
- Ensure actions are equitable and socially-acceptable;
- Address the needs of the more vulnerable sectors of society;
- Address multi-level change (individuals, small collectives, communities, macro-global);
- Take into account the psychological/behaviour change elements and knowledge;
- Avoid fundamentalist stances on climate change – climate change responses need to be subsumed into daily life;
- Encourage experimentation and do not punish failures (adaptive management) – the climate change problem cannot wait for perfect responses;
- Use democratic approaches – people need to participate to feel hope; and
- Operate more flexibly in order to respond more quickly and identify diverse solutions.

Presumably, Moser & Dilling (2004) and Vogel *et al.* (2007) were also focused on policy makers and others with formal climate change responsibilities when they identified a need for people to:

- develop a more empathetic understanding of the difficulty or inconvenience that change and new behaviours involve for people;
- connect climate change issues with those concerns that people feel persistent and personal responsibilities for; and therefore be in a better position to then
- develop alternative actions that provide maximum choice and flexibility and are accompanied by meaningful and persuasive rationale for the required change.

There are strong calls for systematically-designed climate risk communication and engagement approaches that will encourage desired behaviour changes at a broad scale. Certainly the whole 'climate change audience' is broad and diverse. It is important to recognise and accommodate diverse values (including cultural and moral), beliefs, knowledge, interests, social networks, demographics (including culture), as well as understand some of the prevailing mental models relating to climate risk perceptions and responses (Moser & Dilling 2004; Vogel *et al.* 2007; Lorenzoni *et al.* 2006). Making distinctions between adaptation by different actors, can help government/decision-makers distinguish where (and how) they can intervene to most effectively encourage desirable adaptations (Milne *et al.* 2008).

Leiserowitz (2005) recommended that multiple voices and perspectives are needed when making decisions about what will be 'dangerous' levels of climate change (thresholds in social and ecological systems) and finding solutions that will meet diverse needs. Often risk assessments are overly technical and are not sufficiently informed by lay public definitions of 'dangerous', which are more sensitive to technical, social and psychological qualities of hazards (Leiserowitz 2005; Slovic 1999; Pidgeon *et al.* 2006).

Particular audiences will be more or less persuaded by different ***information sources*** (e.g. governments, industry, researchers), depending on how credible and trustworthy those sources are perceived to be (Moser & Dilling 2004; Vogel *et al.* 2007; Botterill & Mazur 2004). It will also be important to match the channel of communication to the goals of such communication. Mass communication channels are more appropriate when the aim is to spread information widely, whereas the goals of soliciting commitment or involvement require more direct and personalised channels (Moser & Dilling 2004).

The way in which climate change is framed will have a significant influence on how messages are received (Yarnal *et al.* 2003). Risk communications should promote increased awareness and understanding of the causes of climate change, given the strong links made between adaptation and understanding why climate change is happening (see O'Connor *et al.* 1999). Certain message frames and images can help trigger the kind of affective and intellectual responses more likely to lead to desired behaviour changes. Overall, the messages and images should promote greater salience of climate change by localising and personalising this phenomenon, and providing people with practical, positive ways to help make a difference (Lorenzoni *et al.* 2006, 2007). These action frames need to be

tailored to different audiences, move beyond merely emphasising negative impacts of climate change, and promote positive consequences of action [see Box 2].

Box 2. Frames and messages for effective climate risk communication

- Begin with messages for which there is the greatest available scientific certainty to ensure audience receives (and therefore retains) intended take home message at the time they are most attentive;
- But still acknowledge uncertainty about climate change impacts, and that they are not easy to control;
- Don't perpetuate fear – but acknowledge that climate change impacts will be significant (even if not catastrophic), and some sacrifices are necessary to protect ecological systems;
- Situate global climate change in local realities;
- Situate action within shorter-term planning schedules (e.g. 10 years versus 20–50 years);
- Include the message that if you do 'x' (a positive action), then you help prevent 'y' (a negative consequence);
- Where benefits of action are more certain, then those benefits should be highlighted (a 'gain' frame), while with riskier choices – success is less certain, the emphasis should be placed on avoiding loss (a 'loss' frame); and
- Encourage "response-ability" (empowerment) and hope by:
  - Providing information about the effectiveness of recommended actions;
  - Addressing people's concerns over costs of actions;
  - Bolstering people's sense of self-efficacy;
  - Appealing to people's desire to be reasonable;
  - Emphasising the important role of individuals in achieving a greater good (e.g. change at small scales makes a difference);
  - Presenting alternative scenarios and visions;
  - Sharing examples of successful adaptations/ mitigations;
  - Providing specific instructions about the recommended actions;
  - Rewarding early action through public and highly visible acknowledgements;
  - Prompting people to remember to take action and;
  - Explaining more clearly and concretely the implications of delaying or not taking action so that inaction is not rewarded.

Source: Adapted from Lazo et al. 2000; Moser & Dilling 2004; Lorenzoni et al. 2006, 2007; Vogel et al. 2007; University of Melbourne 2008

In addition to message design, Lorenzoni *et al.* (2007) noted that greater behavioural change would flow from reforms to some of the wider structural conditions and social norms that tend to perpetuate the 'status quo' rather than facilitating broader scale change. They and others (University of Melbourne 2008) encourage the use of:

- institutions and infrastructure that at individual levels interrupt habitual behaviours and encourage consideration and use of alternatives (e.g. free bus tickets, congestion charging, bike-to-work breakfasts);
- sustained support and positive reinforcement through incentives (e.g. household support, community initiatives); and
- stronger external pressures, such as regulatory and fiscal frameworks that activate mitigation responses to climate change (e.g. the United Kingdom's policy of allocating personal carbon allowances).

Effective engagement of a range of people in climate change (mitigation and) adaptation requires approaches that depart from more conventional forms of risk communication. Those paternalistic models have tended to disseminate primarily scientific and technical information in order to 'educate' a naïve public and shift 'irrational', opposing views to those that are more supportive of various policies and programs. In contrast, more innovative communication models value different knowledge cultures, are participatory and inclusive, and must be enabled through supportive organisational cultures, appropriately skilled personnel, and adequate resources. The media is being encouraged to improve its climate risk communication role. Suggestions include reporting that focuses more on perceptions of risk rather than on the physical facts of climate risks; provides longer term, more consistent and integrated coverage and reduces coverage that sensationalises climate change's catastrophic potential; and avoids overly simplistic, polarised representations of the different positions on climate change. Climate change decision-makers are being encouraged to improve their understanding of the social and institutional factors influencing climate change adaptation; design climate risk communication and engagement approaches that distinguish adaptations by different actors and target their divergent values, needs and interests; and use a range of regulations, policy instruments, and programs that encourage and enable desired adaptations through appropriate information sources, message frames, and incentives.

5.3 Climate change adaptation in agriculture

Progressive (climate) risk communication approaches highlight the social nature of climate risk perceptions and responses, the need to employ participatory approaches in climate change decision-making, and methods for improving the reach and impact of climate risk communications with the

public. These recommendations have considerable synergy with research on improving use of sustainable practices in agriculture, including adaptations to climate change, and encouraging appropriate responses to hazard emergencies.

It is believed that interventions to increase adaptation to climate change can be improved by recognising that agricultural adaptation to climate change occurs at different scales (institutional, regional, farms, individuals) across all sectors of society, and therefore requires actions from a range of individuals and organisations beyond just farmers (Burton & Lim 2005; Reid *et al*. 2007; Milne *et al*. 2008). Furthermore, there are differential capacities (across regions, industry sectors, and farms) for climate change adaptation (Steffan *et al*. 2006; Burton & Lim 2005), which makes it important to identify the resources and attributes of adaptive capacity in regions (Wehbe *et al*. 2006). There are opportunities for and obstacles to adaptation, which are typically generated by a range of non-climatic forces – the broader economic, institutional, and social environment – and those forces interact with local characteristics of farms/farm families to influence different adaptive capacities (vulnerability and resilience) at the farm level (Reid *et al*. 2007; Wehbe *et al*. 2006) [see Figure 1].

Policies and agricultural research and extension programs seeking to improve the use by agricultural industries and farmers of various climate change mitigation and adaptation practices would benefit from using participatory approaches. Such techniques have been found to:

- improve understanding of how and why agricultural systems are vulnerable to climate change (including to climate variability and extremes) (Reid *et al*. 2007);
- promote understanding and appreciation of different values, goals, beliefs, and local knowledge underpinning landholders' current practices (Pannell *et al*. 2006);
- increase the relevance and utility of adaptive measures – and therefore the credibility of experts – by including and making more explicit concepts and features that are important to stakeholders (e.g. linking rainfall records to people's memory of climatic events) (Reid *et al*. 2007; Leith 2006).

Other similar design considerations include:

- applying lessons learned from risk communication about cognitive barriers (promoting consistent, possible, sensible, economical, and sensible adaptation actions) to avoid maladaptive responses like denial of climate risk (Grothmann & Patt 2005);
- focusing less on persuading people to change their values and goals and more on increasing the attractiveness of innovations (those that have high relative advantage, are more readily trialed, and high trialability), using incentives, and valuing people's reasons for not adopting certain practices (Pannell *et al*. 2006); and
- using one-on-one, interactive forms of extension, and drawing on experts who are perceived to be credible and trustworthy (Pannell *et al*. 2006).

O'Neill (2004) developed a framework for fostering protective behaviours in hazardous situations, which draws on adoption of innovation theory and provides guidance on designing actions that large groups of people are more likely to adopt – rather than focusing too heavily on the psychology of persuasion and communication. Noting that different risk perceptions guide people towards their understanding of their own vulnerability to a hazard and their willingness to develop appropriate responses, O'Neil (2004) recommends focusing on different key audiences':

- risk attitudes and perceptions (risk averse, risk tolerant, risk deniers, risk takers), degrees of independence and self-efficacy, and past exposure to particular hazards;
- feelings about experimenting with or adopting new behaviours (e.g. innovators, early adopters, early majority, late majority, laggards, persistent sceptics); and
- motivation and energy levels for investing in different stages of adopting a particular innovation or behaviour.

O'Neill (2004) mapped these features against desired levels of public or community involvement in formulating and implementing emergency management strategies [see Appendix 7]. His model also implies a scale of audience commitment (e.g. innovators – high involvement, early majority – low involvement, sceptics – resistance), and matches goals and strategies to the degree of desired behaviour change (e.g. empowerment and collaboration for innovators; community education/public awareness for early adopters and early majority; social marketing for early majority and late majority; and emergency communications for laggards and persistent sceptics) (O'Neill 2004: 30). Different tools and content would be employed to implement the different strategies.

Collectively, this knowledge can be used to more effectively meet the diverse information and support needs of different audiences/groups who inevitably hold variable views about and desire and capacities to adapt to climate change (Milne *et al*. 2008; O'Neill 2004; Moser & Dilling 2004).

Adaptation to climate change will need to occur at multiple scales and across numerous actors in society. There will be variable capacities for adaptation, which are (positively or negatively) influenced by an array of non-climatic forces. Considerable insights on facilitating climate change adaptations in agriculture can be gained from the research on improving the uptake of sustainable practices in agriculture and effective (climate) risk communication approaches. This body of work advocates for participatory approaches to agricultural policies, research and extension programs that encourage adaptation to climate change, because those initiatives: target vulnerability of systems, communities and individuals; increase the relevance, utility, and attractiveness of agricultural adaptations; and are informed by a range of values, beliefs and knowledge.

6. Summary and conclusion

6.1 A summary of key findings

Climate change (or global warming) has been increasingly acknowledged as a serious and complex challenge for modern society. The warming of the Earth's climate will have significant effects on life as we know it. In south-east and south-west Australia, agricultural industries and rural communities will be particularly vulnerable to the predicted warming and drying trends. The overriding challenge for a range of communities of interest will be to work collaboratively to identify, disseminate and apply the most effective means for protecting ecological systems and regional communities from climate change's deleterious effects and taking advantage of any opportunities. This challenge necessarily involves mitigating those factors which impede progress towards adaptation.

Environmental risks like climate change are far more than technical issues that can simply be eliminated with the 'right' system – responding to climate change is also a social and political matter of determining what are acceptable levels of risks to society(ies) and what can and should be done (by and for whom) to reduce the vulnerability of human and ecological systems[13].

This report has reviewed a wide array of research considered relevant to encouraging adaptation to climate change. The following list presents the major conceptual highlights of this report:

1. Climate change will bring a range of impacts that will manifest at a geographic level, with some regions experiencing greater pressures than others.
2. A combination of climatic and non-climatic factors play a critical role in determining the vulnerability of regions, industries, communities and individuals to climate change impacts. These factors include exposure sensitivity (susceptibility) and the capacity of the system, region, community to adapt to climate change effects and impacts;
3. Sensitivities and adaptive capacities are expected to vary across regions, industry sectors, communities and individuals.
4. There are various prescribed actions for climate change mitigation and adaptation. Uncertainties remain about appropriate frameworks for evaluating their effectiveness, efficiency, appropriateness and sustainability across different temporal and spatial scales.
5. There are patterns of similarity and difference in the way that people think about and respond to risks in general and climate change risks in particular. Recent evidence suggests an increased general awareness of 'climate change', but considerable misunderstandings of the phenomenon persist. A spectrum of climate change positions can be detected among different 'interpretive communities', from low, medium, to high levels of concern.
6. Individual climate change positions (and subsequent choices about how -if at all – to act in the face of climate change) are determined by actors' values, beliefs, feelings and knowledge, including about how much of a threat (risk) people consider climate change to be, how motivated they are to act, and whether they feel they have the ability to make changes/adapt.
7. In addition to their risk and adaptation appraisals, people's ability to act will be informed by their (real and perceived) access to a range and amount of 'resources' needed for any given action (e.g. information, social support, equipment, professional advice, financial assistance).
8. The attributes of any prescribed adaptation practice will also affect people's choices, such as its effectiveness, practical benefits, ease of use, and how it has been designed and disseminated.

There will always be a range of macro-level factors in the broader, operating environment of a range of actors, which – while outside their direct control – nonetheless influence their views and capacity to adapt. For example, the mass media contributes to some of the confusion about climate change. And some climate change adaptations may be restricted by a lack of appropriate incentives, declining terms of trade, and rural/regional decline.

This literature review will become an important working document for the Social Science Project (P2) in Landcscape Logic. The review should also be of interest to others within the Hub, including our regional and State agency natural resource management (NRM) practitioner partners. As social scientists, we have a strong commitment to explaining our theoretical foundations and presenting these as frameworks that can be readily understood. Figure 1 provides an example of how we have attempted to do this.

6.2 Implications for the researchers

This review of social research relevant to climate change adaptation has uncovered useful lenses and/or frameworks that can be applied to future climate change research (and other NRM topics), including:

- the numerous, interacting factors influencing the adoption of different behaviours, in this case

adaptations to climate change [Figure 1];

- viewing climate change as a classic risk issue: this highlights why and how climate change presents particular decision-making dilemmas for decision-makers and offers insights about better ways to communicate with and engage different audiences about climate change (pp. 12–13, Section 3);
- ways to classify public and landholder beliefs/attitudes about and positions on climate change (e.g. pp. 24–25); and
- ways to classify landholder adaptations to climate change (see pp. 17–18, 33–34).

Several research challenges and questions could be pursued. The framework shown in Figures 1 includes a multiplicity of factors relevant to climate change adaptation. Prioritising which of those factors to investigate further is partly a response to research capability of interest in working at different scales: psychological approaches might focus primarily on individual characteristics; social psychology would consider the influence of resource access, nature of the (adaptation) practice, and elements of the broader operating environment on individuals; sociological approaches would prioritise elements of the broader operating environment on communities. We recommend a social psychology approach that focuses on the following topics:

- It would be useful to map the patterns in the ways people think about and respond to climate change in the regions where Landscape Logic is operating using theories developed by Langford (2002) and Leiserowitz (2005).
- It will also be valuable to identify the different kinds of risks landholders are responding to and try to rate them in order of perceived importance to the landholders (McCarthy & Thompson 2007; Grothmann & Patt 2005) and determine the extent 'climate change' is seen as a separate, definitive threat/risk.
- It will be particularly important to identify landholders' perceived self efficacy or ability to respond to climate change risks (Grothmann & Patt 2005; Steffan *et al*. 2006); and what kind of support they think they need and/or have received in order to do so (Weber 2006; RIRDC 2007).
- Researchers should also identify the (extent and type of) different kinds of landholder climate change adaptations; compare them with formal 'best practice' recommendations; and assess the implications of those for the condition of vegetation and water quality (Reid *et al*. 2007; Milne *et al*. 2008; Wehbe *et al*. 2006; Steffan *et al*. 2006).
- It will also be valuable to identify the degrees of support for/trust in NRM policies/practitioners amongst landholders and what information sources are used and deemed credible, reliable, and useful (Slovic 1999; Curtis & Byron 2002; Curtis *et al*. 2006).

6.3 Implications for NRM practitioners

Landscape Logic includes a diversity of partners, and its work is potentially applicable to a wide audience of natural resource management (NRM) practitioners and researchers working at national, state, and regional scales (e.g. Commonwealth and State agencies, research institutions, Landcare Coordinators, and community groups).

The Australian Government's Department of Climate Change recently identified 'climate change' as ''core business'' for regional NRM organisations – impacting on numerous ecological, hydrological and resource-degrading processes and therefore affecting virtually every NRM issue relevant to these organisations (Campbell 2006; DCC 2008e). It has been suggested that on-ground investments by regional NRM bodies will not necessarily need to be radically different under climate change scenarios, as best practice NRM is expected to alleviate existing climate pressures through actions such as improving land use planning and agricultural practices; restoring landscape connectivity; managing invasive species; targeting provision of environmental water; and improving water quality (Campbell 2006: vi). This might be an overly optimistic assessment, as responses that include dam building/extension, increased irrigation in upland catchments and perennial pasture establishment are likely to have substantial impacts on water flows in the southern sections of the Murray-Darling Basin.

Nonetheless, climate change certainly adds additional layers of complexity and uncertainty to the overall task of regional NRM. In response to these uncertainties and complexities, adaptive management[14] has long been widely prescribed as an alternative to conventional technocratic management paradigms used in NRM (Bellamy *et al*. 2001; Allan *et al*. 2008), as well as for climate change policy and management (Peterson *et al*. 1997; DEH & AGO 2006). Climate change policies and management under adaptive management would ideally stand up to uncertainties, test alternatives, provide opportunities for learning, and monitor and evaluate outcomes (Peterson *et al*. 1997).

Social scientists argue that a key tool to support adaptive management is recognising the social dynamics that underpin resource management (Allan *et al*. 2008). Regional NRM bodies make a range of decisions about how public funds will be used to address an array of resource management challenges (Campbell 2006). The 'success' of those decisions is determined, not just by biophysical possibilities and economic feasibility, but by

what is deemed socially-acceptable: judgements about physical and scientific facts combined with knowledge of alternatives and their consequences and trust in decision-makers (Allan *et al.* 2008). Consequently, resource managers require a range of knowledge and skills in order to bring diverse stakeholders together to develop shared understanding and more collaborative approaches to addressing highly complex and uncertain challenges such as climate change.

The specific social information needs of regional NRM practitioners will vary according to the particular nature of their resource management responsibilities, challenges, identified priorities, and previous and current approaches to and capacity for knowing and engaging their stakeholders and broader communities. However, this research suggests several broad areas that potentially would assist many organisations seeking to address climate change issues.

6.3.1 Assessing the vulnerability of key assets

Regional NRM bodies are being encouraged to identify the vulnerability of their key natural resource assets to climate change (Campbell 2006; DCC 2008e). As the IPCC suggests, we currently lack appropriate methods for integrated assessments of climate change impacts at the local/regional scale (Hennessy *et al.* 2007; see also Preston *et al.* 2008). In addition, further dialogue is needed about appropriate roles and responsibilities and required levels of collaboration and coordination among different levels of government and other actors for undertaking such assessments.

There are a broad range of assessment models and methodologies. Regional NRM managers who may lead and/or participate in regional vulnerability assessments, should consider models that:

- are interdisciplinary and involve a diverse range of stakeholders, particularly members of the community whose livelihood, health and/or overall well-being might be affected by climate change;
- are sufficiently localised: drawing on regional/local knowledge and capacity, relevant to regional/local characteristics, and suitable for application at regional/local scales;
- include an assessment of the range of possible 'risks' (likelihood and magnitude of – positive, negative – consequences) of exposure to climate change;
- utilise some quantitative measures of the magnitude of risk, vulnerability, and impacts, that enable rating of the risks and thereby support priority setting; and
- account for the influence of non-climatic (and other bio-physical) factors on adaptive capacity and resilience.

6.3.2 Increasing adaptive capacity (and resilience)

Regional NRM practitioners have a role in positively influencing farming systems and practices (Campbell 2006). Given this role, information could be gathered that reflects the framework illustrated in Figure 1, and is consistent with earlier studies providing management authorities with information about progress towards NRM objectives and insights about landholders' engagement, including:

- limitations/barriers/constraints to the adoption of sustainable land management practices, particularly potential or actual climate change adaptations (and mitigation);
- alternative enterprises or new technologies available to improve the sustainability of the farm system;
- the geographic basis of current management units to enable easier implementation of policy changes;
- attitudes towards current tools and potential alternative tools for improved land management; and
- a methodology that will enable the work to be repeated in the future (see Curtis & Byron 2002; Curtis *et al.* 2006)[15].

6.3.3 Knowing and communicating with stakeholders and the regional community

The role of regional NRM practitioners is not limited to influencing land management practices and includes protecting a wide range of natural assets in their area. They will therefore need to engage a diverse audience, not simply farmers. It would be useful to build a (or complement any existing) social profile of their respective communities that includes information about:

- the nature and distribution of stakeholder and community beliefs in climate change, including the degree of perceived threat relative to other issues; and
- the level of broader social resilience and adaptive capacity in the region.

If NRM practitioners of all types are seeking dialogues with (rural, regional, agriculturally-dependent) communities and landholders, those conversations need to be targeted, interactive, and inclusive. There will also be a shared responsibility among decision-makers at a range of scale to identify ways to increase the attractiveness of climate change adaptation (and mitigation) practices.

The following principles should guide the development of effective communication and engagement strategies:

- Recognise the diversity of climate change audience and match information provision to audience needs and interests.
- Clarify the goals of engagement with different audience and use appropriate tools (e.g. if spreading information widely, use mass communication techniques; when seeking stakeholder or community involvement, use direct, personalised approaches).
- Recognise and address the needs of the more vulnerable sectors of communities.
- Extension services for land management that employ one-on-one, interactive approaches, and draw on experts seen as credible and trustworthy by their respective audiences are likely to be successful.
- Provide institutions and infrastructure that interrupt habitual, undesired behaviours and encourage consideration/use of alternatives (e.g. 'breakfast fora' for farmers to engage climate scientists, fuel discounts for minimum-tillage croppers, subsidised rainwater tanks & solar panels).
- Use approaches that provide maximum choice and flexibility and combine positive reinforcement with some external pressure (e.g. regulatory, fiscal frameworks).
- Use messages that connect climate change issues with concerns people feel persistent and personal responsibility for.
- Use messages that acknowledge uncertainty and how climate change effects are not easy to control, but start with what is most likely to ensure audiences hear and retain the intended 'take home' message.
- Use images that trigger appropriate affective and intellectual responses – seek to enhance the salience of climate change by localising and personalising it. Avoid scare-mongering and combine those messages with information about practical ways for people to make a difference.
- Work within time frames that are more easily appreciated by people (e.g. alternative visions and scenarios 10–20 years into the future rather than 30–50 years).
- Promote not just negative effects of climate change, but also the positive consequences of action (e.g. ''response-ability''). Where the benefits of action are more certain, then highlight them. Where success is less certain, highlight the potential to avoid loss from climate change impacts.

Communication frameworks, such as that developed by O'Neill (2004) (see p. 45 & Appendix 7), can be used to help deliver these principles and techniques. O'Neill's (2004) framework targets the reasons why people adopt certain behavioural changes, integrates that with their different responses to hazards and risks, draws on proven theory and best practices in community engagement – which could be used to help design and deliver communication and extension activities relating to climate change adaptation.

Endnotes

1. Fussel (2007) identified compensation (payments or assistance from those countries who disproportionately contributed to climate change to those who disproportionately suffer from it) as a third, albeit less popular, policy option.
2. For example: regional-based climate information and tools, integrated (regional) vulnerability assessments.
3. These include but are not limited to agriculture, biodiversity, fisheries, forestry, settlements and infrastructure, coastal, water resources, tourism and health.
4. This perspective emphasises agriculture as a system.
5. Generally, people are more vulnerable when they feel they have little or no control over causes of problems, do not know how long the stress will last or how intense it will be, see stress as evidence that circumstances are worsening, and lack social support for the duress that the stress causes (Eckersley 2007).
6. In addition, resilience can be described as seeing 1. good outcomes irrespective of particular risk factors; 2. constant competence under stress; and 3. recovery from trauma.
7. The countries covered in the review included China, India, Mexico, Russia, the United States, Canada, France, Germany, Italy, Japan, the United Kingdom, Brazil, and South Africa.
8. Lorenzoni *et al.* (2006) found that American and British views were similar in this regard.
9. These models of risk communication are referred to as a 'technical' approach (Rowan 1994 cited in Gutteling & Kuttschreuter 2002: 36) or 'deficit' models (Parliamentary Office of Technology 2001: 4; Jones 2005).
10. See Bammer & Smithson (2008) for an extensive multi-disciplinary discussion on uncertainty and risk.
11. Some of the obstacles to more effective public risk dialogues include: a lack of communications training, time for scientists or policymakers to be involved, low confidence among scientists to engage with the social and ethical implications of their work (MORI 2000), lack of perceived relevance and benefits among policy and scientists of wider, interdisciplinary risk-based approaches to environmental governance (e.g. broader notions of expertise, engagement, and advice); and organisational cultures that support those attitudes (Jones 2005).
12. Risk communication researchers identified the need for improved knowledge and skills in: more complex analyses of communities and of the political and social values shaping risk perceptions (including their own); methods of communicating with and engaging diverse communities, and mediating between competing interests; and ways to incorporate more diverse forms of knowledge/expertise and aspirations into policies and programs (e.g. negotiation/conflict resolution and management) (Marsh 2001; Finucane 2000; Parliamentary Office of Technology 2001).
13 Adapted from Zinn & Taylor-Gooby (2006: 54-56) who identified a need for continued interdisciplinary work in risk research that, among other things, targets not just the efficacy of new and untried technologies, but considers how to define what are/will be acceptable levels of risk.
14. Adaptive management is a cycle of practice emphasising continuous change, reflection, and learning to improve the way policy and management contributes to more sustainable use of resources (Bellamy *et al.* 2001; Allan 2008; Leverington *et al.* 2008). Allan *et al.* (2008: 168) listed its defining characteristics: management activities designed to test hypotheses through ecosystem-scale, holistic experiments; active reflection on the outcomes of those management activities; provision of mechanisms for multi-disciplinary and multi-stakeholder involvement; an emphasis on collaborative or participatory social learning; provision of mechanisms for incorporating learning into planning and management; and development of appropriate communication fora for all project participants.
15. The data collected for those information needs included: Assessment of issues affecting property and district; self-assessment of knowledge and awareness of different resource management topics; views about roles and responsibilities for natural resource management; long-term plans for the property; involvement in succession, property, and business planning; adoption of recommended practices; other property data (e.g. property size, broad enterprise mix, remnant bush, area under specific enterprises); background socio-economic data (e.g. age, gender, education, occupation, on and off-property hours worked, on and off-property household income, group memberships, access to government funding, time in district, level of equity in property and place of residence) (Curtis & Byron 2002: 15).

Appendix 1. Barriers/constraints and drivers to climate risk management and adaptation

	Barriers	Drivers
Personal characteristics		
Values & beliefs, feelings, knowledge	Weak environmental values Low awareness/understanding of climate change Low self-efficacy Feelings of being overwhelmed Lack of clear ideas	Strong environmental values Strong belief in climate change and understanding of causes Direct experience of climate change impacts High self efficacy
Risk perceptions	Low perceived threat & likelihood of climate change	High perceived threat and likelihood of climate change High perceived benefits, low perceived costs of action High trust in climate science
Motivation	Low perceived benefits, high perceived costs of action	Strong sense of a (moral, practical) need to act
Resource access		
Human capital		Higher education, better informed Greater professional experience
Social capital	Pervasive social norms prescribing high living standards	Strong community leadership and vision, supportive of climate change adaptation Wider network of advisors
Financial capital	Poor market access Lack of credit/savings Low levels of capital to cover high input costs associated with production changes	Economically viable business Higher levels of capital
Physical	Lack of adequate farm and/or regional infrastructure	
Natural	Low access to water Degraded land	Larger farm size
Characteristics of practice, technology, service	Lack of information about climate change sufficiently localised, accessible, & originated from trusted sources Inconsistent/contradictory, confusing tone and content of climate change communications	Previous local success of NRM innovation programs Delivery of extension services by credible, trusted local people Appropriate design of extension services (e.g. interactive, informal) Appropriate incentives
Operating environment	Social norms & expectations: e.g. public scepticism Lack of enabling social institutions and infrastructure/mechanisms for environmentally-friendly services, products Fluctuating political/policy cycles, lack of action Mass media Certain aspects of water planning & allocations Globalisation Declining terms of trade Narrow economic base in rural/regional centres Climate change impacts	Certain aspects of water planning and allocations Mass media Climate change impacts

Appendix 2. Recommended agricultural adaptations to climate change

Principal direct physical and ecosystem impacts	Potential adaptive response
Intensive livestock	
Increased heat stress of stock	Breed improvement, appropriate shade/infrastructure
Increased maintenance animal health – increased pests and diseases	Develop projections for range changes of pests and diseases, monitoring and early intervention
Reduced supply of feed – likely impacts on both the business's ability to produce pasture & crops and buy-in grain.	Increase resilience of plant production systems, adapt annual production cycle to match feed production
Reduced reliability and quality of water supply to stock	Whole of business water planning & optimisation
Extensive livestock	
Reduced pasture productivity Reduced herbage quality	Introduce increased drought tolerant species, Increase use of strategic spelling
Changes to the dynamics of pests, diseases and weeds	Increase monitoring & increase adoption of Integrated Pest Management (IPM) practices
Increased soil erosion and nutrient movement into waterways Reduced carrying capacity	Increase use of dietary supplements, implement responsive stocking rate strategies
Increased animal health and husbandry challenges	Breed selection, increase shade trees, monitor pests and diseases for early intervention
Reduced reliability and quality of water supply to stock	Whole of farm water planning & optimisation
Extensive cropping	
Increased variability and changes to seasonality of rainfall	Diversify farm enterprise, opportunistic planting
Reduced soil moisture	Zero till practices, crop/cultivar selection
Changes to the dynamics of pests, diseases and weeds	Increase monitoring and adoption of IPM practices
Increased heat shock/stress	Timing of planting, cultivar selection
Reduced grain quality/nutrient content	Match optimised nutrient application to season
Increased yields in higher rainfall areas due to decreased incidence of soil water logging	Integrate cropping into higher rainfall regional business plans
Intensive cropping (horticulture/viticulture)	
Decreased frost frequency	Variety selection, shift in production area
Increased temperature & CO_2 (altered water demand, changes to sowing and harvest time)	Secure water supply, improve water management Revise production schedules to maintain yield/meet market demand
Altered range and incidence of pests and diseases	Increase monitoring and adoption of IPM practices
Reduced quality (nutritional, appearance due to water/ temperature stress, and increased CO_2 concentrations)	Modify fertiliser regime, alter production cycle to avoid extremes

Source: DCC 2008b

Appendix 3.
Social science approaches to risk perceptions

Type of approach	Description
Engineering Technical risk analysis	Technical problem of calculation & public acceptance Expected gains and losses can be translated into objective measures (probability x extent of damage) Seeks controlled, safe, reliable technical systems & processes
Behavioural economics and cognitive psychology	Analysis largely at level of individual Emphasis on rational action & seeking evidence of paradoxes and inconsistencies in people's dealings with risk Cognitive illusions & distortions influence perceptions, including emotions Responses influenced by way issues are presented
Heuristics and decision-making	People rely on limited number of principles to simplify complex task of assessing risks (e.g. representativeness, availability, anchoring, adjustment)
Framing	Formulation of the problem influences risk judgements; formulation influenced by norms, habits, & personal characteristics of person
Mental modelling	People develop conceptual structures corresponding to risks as they understand them; structures have varying degree of 'accuracy' and can be mapped Draws on decision-making & psychometric approaches, but uses qualitative methods to elicit lay understanding of risks and to compare/contrast those with expert perspectives Laypeople have simpler, more intuitive mental models, influenced by cognitive biases resulting from particular heuristics
Social psychology	
Psychometric paradigm	Conceptual models of reality people construct; how they differ from those based on expert knowledge Seeks understanding and prediction of public risk preferences Risk is subjectively defined by individuals who are influenced by wide array of (relatively stable) psychological, social, institutional & cultural factors Use of quantitative method to identify expressed risk preferences (hazards); hazard characteristics which explain most of variance in views
Social amplification of risk	Combines risk perception and risk communication into a framework seeking to account for ways risk events are perceived and influence society Social processes influencing perceptions: channels of communication, role of social institutions in modifying signals, individual characteristics/factors (e.g. heuristics) Risk messages ripple out via a widening range of social groupings
Emotion and affect	Counters notion that emotion contradicts rationality; emotions and rationality necessarily interact to direct decision-making Feelings have a direct effect on decision-making Affect (feeling or emotion) as an orienting mechanism: primary response from which risk & benefit judgements are derived (in part) Emotional intensity significantly influences risk perception and risk taking: low level of intensity people evaluate their feelings to decide how to judge the risk; intense emotions might cancel out cognitive consideration (e.g. dread of consequences) Includes 'edgework' – emotions as a pre-requisite for action as well as informing degree of enjoyment of/need for risk-taking (e.g. extreme sports, arson)
Sociology	Culture and institutions as the key determinants of risk
Expert-layperson approach	Early research assumed superiority of scientific & professional knowledge; key differences explained in terms of limited knowledge & misunderstandings of reality Later work focusing on value of layperson knowledge, its values & positions; how expert knowledge is involved in social process of knowledge production
Socio-cultural approaches	Different ways risk is understood by different people, how people construct their identities & membership of social (sub)cultures referring to risk, how people interpret risk as positive and negative Individual's perception and response to risk can only be understood as function of their socio-cultural background and identify as member of a social group versus individual cognition Degree to which individuals' lives regulated or prescribed by roles in a social group and degree of identification with a particular group

Risk society	Social change & modernity: risk perceptions evolve from worldviews based on enlightenment, technological advances of Industrial Revolution, social and political changes following development of working class, division of labour, expansion of internal system of sovereign states, political economy of national economic management based on growth Qualitatively new risks emerging – independent of people's social status (BSE, climate change) Cannot be solved readily based on available information; effects & causes partially understood, with science failing to supply knowledge required for management within current policy frameworks Uncertainty a fundamental experience of modernity
Governmentality	Draw on Foucauldian analysis of societal governance: analysed power & domination in society and how these are transformed in the development of the modern state (e.g. neo-liberal power strategies changing relationship between state and economy, whereby all human action is characterised by economic rationality re: allocation of limited resources) Considers how responsibility for societal risks (illness, unemployment, poverty) is transferred to the collective and to individuals Risk & security are central elements of power and domination and so a strategy for governing societies Risk is not objective, but a way to conceptualise and render controllable aspects of reality
Risk governance	Informed by interest in public acceptability of risky decisions and how decisions can be made in more publicly acceptable ways Shifts risk from technical question to focus on ideas of democracy and public participation Assumes public participation can increase public acceptance of risk decisions
The media	Assumes media exerts significant influence on social identities, risk definitions, risk selection and people's knowledge about risk: media frames public understanding of risk Later work acknowledging complexity of media's role in society; some work on social and political context of risk reporting
Trust	Assumes public trust in expertise, science & politics has declined since 1980s; trust is easier destroyed than built; trust is required for building public acceptance Psychological approaches: characteristics of agency to be trusted (competence, objectivity, fairness, consistency, care, faith); attitudes towards a risk issue Sociological approaches: includes self-confidence plus trust in worldviews, institutions, abstract systems, other people

Source: Adapted from: Zinn & Taylor-Gooby 2006; Leiserowitz 2005; Stedman 2004.

Appendix 4.
Limitations of social science approaches to risk

Type of approach	Limitations
Engineering **Technical risk analysis**	Requires fully available knowledge of relevant risk and shared values re: its status, priority, management
Behavioural economics and Cognitive psychology	Responses influenced by the way issues are presented
Heuristics and decision-making	Conducted primarily as experiments; can lack direct information re: people's 'real life' judgements
Framing	
Mental modelling	Fails to question extent of uniformity/consistency, objectivity of expert knowledge Validity of lay knowledge of risk given context in which they are encountered Trust influences acceptability and therefore authority of expertise
Social psychology	
Psychometric paradigm	Condenses information into quantitative averages Neglects influence of knowledge, values, feelings Tends to neglect socio-political variables that might influence perceptions Power to generalise reduced by influence of dynamic cultural contexts Unclear connections between measured risk perception and practical, daily responses
Social amplification of risk	Limited predictive power – does not generate testable hypotheses Oversimplifies role of media
Emotion and affect	Emotional intensity significantly influences risk perception and risk taking: low level of intensity people evaluate their feelings to decide how to judge the risk; intense emotions might cancel out cognitive consideration (e.g. dread of consequences) Includes 'edgework' – emotions as a pre-requisite for action as well as informing degree of enjoyment of/need for risk-taking (e.g. extreme sports, arson)
Sociology	Insufficient attention to interweaving of culture and individual perception and responses to risk, and way these factors change/develop over time
Expert-layperson approach	Can limit characterisation of individuals into simplistic dichotomies, neglecting variation across and within social groups
Socio-cultural approaches	Disagreement re: degree to which other attitudes associated with risk sensitivity (fears) explain risk more than heuristics and other variable (dread, customary risk) and cultural factors Culture presented as additional and independent, not as underlying factor Concern about ability to capture via structured questionnaires Qualitative approach of groups as heuristic overly schematic to capture complexity
Risk society	Disputes re: when risk emerged as a modern social concern Too little attention is paid to differences between social groups Neglects cultural and psychological dimensions (e.g. emotional and aesthetic dimensions, choice in individual action)
Governmentality	Over-reliant on top-down functionalism: people as inherently open to manipulation and not addressing notion of agency Can have narrow focus on level of national governments
Risk governance	New knowledge shows participation alone is insufficient and the ideal of consensus not always attainable Need to include moral considerations into defining what is publicly acceptable
The media	Oversimplification of attitudes to media (e.g. ambivalence, distrust towards media information) Media only one of factors influencing risk judgements and responses
Trust	On-going debates re: complexity and number of dimensions involved in trust (information sources, risk policy processes, value consistency/conflicts of institution and individuals) importance of trust in risk perception relationship between trust, risk judgement, and acceptability of risk; role of cultural differences and of affect source of mismatch more about factors influencing how risk messages are received versus interaction of assumptions of laypersons and experts

Source: Adapted from: Zinn & Taylor-Gooby 2006; Stedman 2004; Leiserowitz 2005.

Appendix 5.
Tactical and strategic approaches to climate risk management

Strategies	Tactical	Strategic
Production	Retaining or reducing labour, undertaking longer working hours Reducing stocking rates Selling off stock, retaining breeding stock Selective watering Removing land from production Rotational grazing Sourcing feed from different places Buying or selling water	Using water efficient technology (e.g. drippers, micro-sprinklers) Conservation farming Improved climate forecasting Expanding farm size Storage of fodder Minimum till farming Upgrading labour skills (e.g. use of new technologies) Diversifying on-farm activities
Business	Reduced spending (personal, capital items) Use of Farm Management Deposits	Implementing increased efficiencies (e.g. administration) Diversifying off-farm activities Exiting farming/rural industry

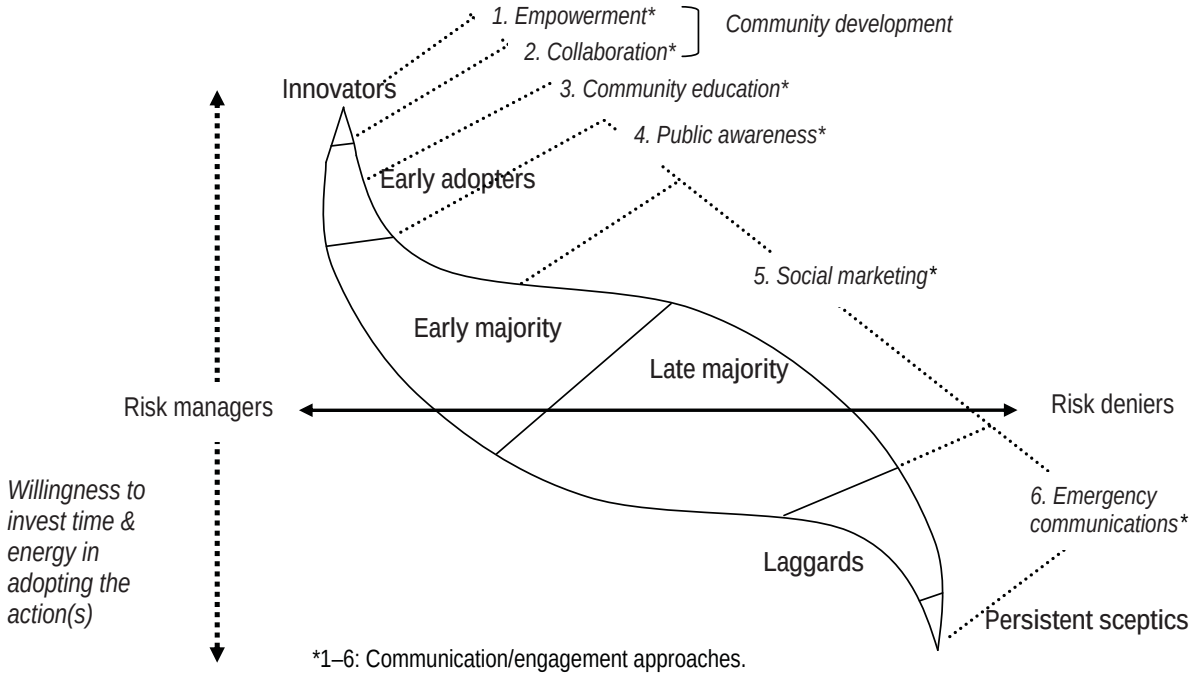
Source: Milne et al. 2008: 56.

Appendix 6.
Climate change adaptation research approaches

Discipline	Focus/Approach
Climate change impact assessment	Most widely applied in agricultural context, specifying future climates and effects; Recent shift to focus on agricultural systems and their sensitivity to climatic conditions – including variations and extremes, and adaptation processes.
Natural hazards	Explores interactions of humans and their environment, with specific focus on impacts of and human responses to extreme events; Key factor in understanding coping and adaptation are characteristics of system being impacted and perceptions of hazard risk (e.g. those presented by climate change); Considers adaptation directly related to perception of risks and involves conscious (planned) decision-making.
Agrarian political economy	Emphasises role of institutions and macro-level forces in agri-food sector; Recognises adaptation at field/farm level – and seen as a process greatly influenced by broader economic, political, and social forces; Includes policy initiatives as 'adaptation'.
Innovation adaptation	Looks at decision-making by which (largely technical) adaptations to climate change are implemented by producers and diffused among farming communities; This decision-making is multi-faceted: determined by situational circumstances of decision-maker & characteristics of innovation, and occurs within changing economic, social, political and biophysical conditions; Informs an understanding of the process by which adaptation options are implemented and their likelihood of adoption.
Agricultural systems & farm decision-making	Agriculture as a complex system where changes driven by economic, environmental, political and social forces which are interconnected; Farm decision-making an on-going process, includes short & long term decisions to manage risk from variety of climatic & non-climatic sources.
Risk management	Climate change a pervasive source of risk in agriculture; Greater focus on farm-level risk management strategies given uncertainty characterising changing and variable climatic conditions; Decisions involve risk assessment and specific action to reduce, hedge, transfer, mitigate risk; Identification of sources/types of farm-level climate risks and how to be managed through adaptation.
Agricultural vulnerability and adaptation	Agricultural systems are sensitive to certain attributes, which need to be understood to address climate change implications; Sensitivities provide targets for adaptation initiatives; Examines types of adaptation tried for responses to climate stimuli and conditions for making adaptive decisions.

Source: Adapted from Smit & Skinner 2002; Reid et al. 2007.

Appendix 7.
Mapping risk communication approaches against different levels of involvement



Source: O'Neill 2004: 30.

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