Climate Adaptation

Key messages

Australia's increasingly variable climate poses challenges for horticulture, given the sector's dependency on natural resources, especially water for irrigation, and temperature sensitivity. This makes horticulture inherently vulnerable to the impacts of both short-term climate variability and long-term climate change.

Climate change will lead to changes in horticulture:

- Some production regions will become more productive in the short term;
- Crops and/or varieties may need to change; and
- Some production regions will become more marginal or less productive.

The impact of climate change on horticulture will differ depending on location, industry, production season, supply chain and timeframe. However, this uncertainty of impact is not a reason for complacency or delay. Producers can respond to these challenges, especially if they focus on climate change as being another business issue requiring risk management. Growers need to be considering future resilience now and developing adaptation pathways to ensure a productive and secure future for their activities.

Many climate adaptation options for horticulture are similar to existing 'best practice' and good natural resource management, and do not require farmers to make radical changes to their operations and industries in the near term. These options can, and should, be prioritised as part of a 'no regrets' or win–win strategy for agriculture because they will provide immediate and ongoing benefits as well as preparing the sector for climate change.

Off farm, the sector needs to consider whether the infrastructure and services on which it relies on (e.g. port and wharf facilities and road networks) are being prepared for a different future climate.

Further research, development and extension is needed for the provision of appropriate data and decision support tools to allow the rapid (and cheap) assessment of climate risk and the identification of possible adaptation measures, and estimates of associated costs.

Climate change and uncertainty

Climate change is the term used to refer to changes in long-term trends of environmental factors such as temperature and rainfall. These changes can be due to natural variability or as a result of human activity, or a combination of both.

Some things about Australia's future climate are fairly certain: there will be more hot days and those days will often be hotter; sea levels will rise; and extremes such as heatwaves, droughts and storm surges are likely to become more frequent and intense.

Other things are less certain: the rate and magnitude of change depends on how sensitive the climate system is to greenhouse gases. Beyond mid-century, it also depends on future emissions, making it sensitive to our success in reducing greenhouse gas emissions now and into the future. Rainfall projections are less certain. While it seems likely that the southern part of Australia will become drier, there is less confidence about northern Australia and parts of the eastern seaboard. We have limited information about how climate change will affect some extreme events such as cyclones and hail storms.

Furthermore, climate change will not proceed smoothly for a given change in heat radiation from changing greenhouse gas levels. There is a risk of abrupt changes as the climate shifts from one state to another as a result of feedbacks and thresholds in the climate system. This will mean increased risk for growers and changes in the way crops are grown.

Further references and resources can be located at the end of this chapter.

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While some of this uncertainty can be reduced by better science, some residual uncertainty will always remain. Understanding the likely future changes to climate makes it possible to start drawing up action plans at national, state, regional and local levels to adapt to the most likely changes.

For further information on GLOBAL scenarios visit http://www.ipcc.ch/

In Australia, detailed climate change information is available via the Ozclim website (www.csiro.au/ozclim). Ozclim provides an interface that can produce maps and data for Australia that show the predicted values for a range of climate variables. This data can be used as inputs to crop models or to derive an estimate of the change of an important temperature variable for a key event in crop production (e.g. the timing of flowering or fruit set).

Climate change resources:

Intergovernmental Panel on Climate Change (IPCC) website: www.ipcc.ch
United Nations Framework Convention on Climate Change (UNFCCC) website: www.unfccc.int
Australian Government Department of the Environment: www.climatechange.gov.au
CSIRO http://www.csiro.au/Outcomes/Climate/Climate-Change-Book.aspx
Climate Change Research Strategy for Primary Industries (CCRSPI): www.ccrspi.org.au
Food Climate Research Network: www.fcrn.org.uk
Tyndall Centre for Climate Change Research: www.tyndall.ac.uk
UK Climate Impacts Programme: www.ukcip.org.uk
Stockholm Environment Institute: www.sei.se

Climate change adaptation

Adaptation is the ability to adapt to unavoidable climate change. Adaptation can occur in a planned manner in response to known changes, or in an autonomous manner as farming systems change gradually over time.

For horticulture, adaptation is a response to the impacts of changing environmental factors such as temperature and rainfall on production systems. It should include both strategic preparation and tactical responses to suit the range of likely climates and variables.

As global climate change progresses, historical conditions may become increasingly less pertinent as a guide to industry activities or industry adjustment. Industry and farm managers will need to distinguish between 'old climate expectations' and 'new climate realities' in determining and implementing new adaptation strategies or options.

Successful adaptation incorporates the development of flexible, risk-based approaches that deal with future uncertainty and provide strategies that are robust enough to cope with a range of possible local climate outcomes and variations.

Further references and resources can be located at the end of this chapter.

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Climate adaptation

Climate change adaptation resources:

UNFCCC on adaptation unfccc.int/adaptation/items/4159.php
CSIRO Climate Adaptation Flagship: http://www.csiro.au/Organisation-Structure/Flagships/Climate-Adaptation-Flagship.aspx
National Climate Adaptation Research Facility http://www.nccarf.edu.au/ and specifically the Primary Industries Adaptation Research Network www.piarn.org.au
Australian Government Department of Agriculture http://www.daff.gov.au/climatechange/climate/adaptation-strategies
WeADAPT: www.weadapt.org

Some state based policy initiatives can be found at:

NSW	http://www.environment.nsw.gov.au/climatechange/adaptation.htm
SA	http://www.sa.gov.au/topics/water-energy-and-environment/climate-change/adapting-to-climate-change
QLD	http://www.ehp.qld.gov.au/climatechange/centre/informationdata.html
TAS	http://www.climatechange.tas.gov.au
VIC	http://www.climatechange.vic.gov.au/adapting-to-climate-change/Victorian-Climate-Change-Adaptation-Plan
WA	http://www.walgaclimatechange.com.au/policy.htm

Increasingly adaptation plans are being developed at a local or regional level.
The NCCARF local government portal is an entry point for more information on adaptation strategies at a local level http://www.nccarf.edu.au/localgov/
Industries are also developing climate resources. See http://www.vegetableclimate.com

Climate risk management framework

The first step for adapting horticulture to climate change involves helping producers to understand why adaptation is needed now – as decisions made now will either increase or decrease vulnerability to future climate change.

A risk management framework is a structured approach to identifying impacts, risks, opportunities and desirable actions. This approach has been widely used in many contexts (such as workplace health and safety) but can be applied in assessing risk of climate change impacts.

There are examples of climate change risk management frameworks in other agricultural sectors, such as the Climate Change Risk Management Matrix developed for the beef industry. Because of the diversity and complexity of horticulture sector it has been too difficult to develop a generic climate risk management framework.

However, the following diagram describes the process required to identify risk and quantify adaptive capacity in order to prioritise options that can be implemented to reduce vulnerability to climate change.

Further references and resources can be located at the end of this chapter.

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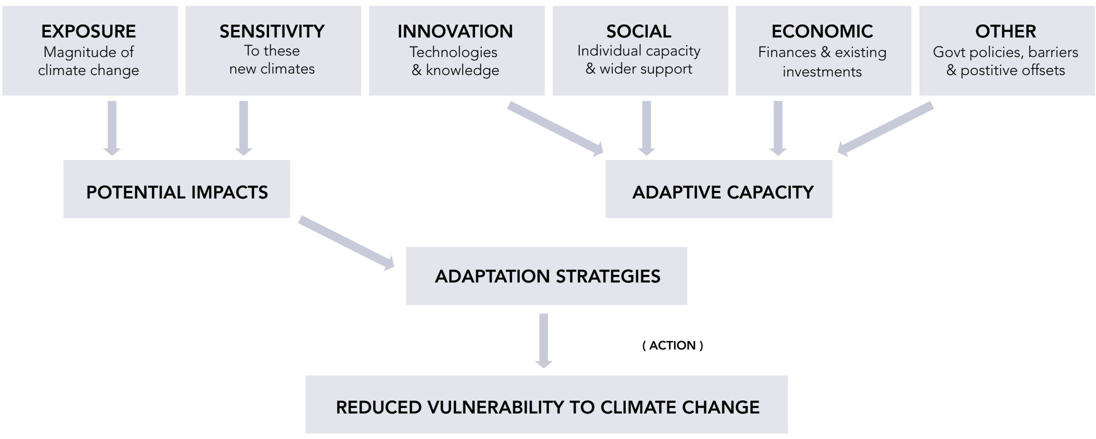

Figure 1: Generic risk management framework.
Source: Adapted from Stokes & Howden (2011)

In general terms, the risk management framework provides an approach to:

- Identify potential risks and hazards for each element of an activity;
- Assess the possible consequences of these risks;
- Estimate the likelihood of each risk;
- Determine a level of exposure or vulnerability (determined from a combination of likelihood and consequence); and
- Identify options to manage or adapt to the risks and consequences.

There is evidence whereby such a risk framework has worked well with horticultural producers. For example, the beef risk management matrix was recently translated for use with tomato growers in the Granite Belt, QLD. This project demonstrated how successful the matrix was in identifying how vulnerable the industry was, what growers could do about it, and the limitations of adapting to climate change. Growers concluded that best practice/good agronomy was going to be their greatest defence against many potential impacts of climate change.

Similar approaches and conclusions have been derived specifically for the apple and pear industry, cherry industry (for both 'Kordia' variety and major cherry production regions), the Queensland cut flower industry and the vegetable industry. In addition, a project was undertaken to document critical temperature thresholds for a number of major horticultural commodities.

The following sections provide further detail on the components of the risk management framework, i.e., impacts, adaptive capacity and adaptation strategies.

Potential impacts

Some of the potential impacts on horticultural production resulting from climate change include:

- Changes in the optimum growing period or season (e.g. frost frequency);
- Shifts in optimum production locations;
- Changes in the distribution and/or abundance of pests, diseases and weeds;
- Reduced availability and increased cost of irrigation water in most locations and in some seasons;
- Increased incidence of temperature-related disorders;
- Increased risk of impacts on product quality and/or nutrition;
- Changes in the suitability, availability and adaptability of cultivars; and
- Damage from extreme events (rain, hail, wind and heat stress).

Further references and resources can be located at the end of this chapter.

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It should be noted that, for horticulture, it's often discrete events or 'secondary' conditions that have the potential for greater impact. For example, it is not just increasing mean temperature, but rather the change in the number of chill hours, timing of frosts, heat events, implications for crop thresholds, duration/timing of these events etc., that have the potential for highest impact. The impacts of these discrete events are highly crop-specific.

In addition, the current policy uncertainty has implications for the sector. The carbon price and associated Carbon Farming Initiative will impact on energy and water prices, influencing irrigation/cooling costs etc.

The extent that these impacts affect horticultural products, and businesses will be further shaped by:

- The magnitude of climate change locally and how strongly each amount of change affects farm productivity;
- Growing global demand for food and productivity growth;
- Continuing uncertainty/development of both global and domestic climate change policy;
- Increasing competition for natural resources; and
- Requirements for ever more efficient and sustainable production practices.

Adaptive capacity

Growers are the primary agents of adaptation - they will need to assess the risk, identify options, make a decision, fund and then implement the action. Governments, researchers and industry people will need to continue to provide the information and tools, but all the rest is up to individual growers.

Adaptive capacity can be influenced by the following:

- Access to technologies that enable adaptation, such as irrigation technologies;
- Individuals 'health, age and life stage' that will influence their capacity and motivation to make decisions, achieve output, adapt to new situations and adopt new practices;
- Industry services, such as group relations, partnerships, norms and networks, which facilitate the diffusion of knowledge and innovation, provide support during structural adjustment and promote cooperative behavior; and
- Supporting policies, such as the policies adopted by government at various levels and the signals they send to producers and others in the food chain.

Successful adaptation is likely to be helped by considering the system-wide consequences of proposed adaptation measures at all social levels, at all points in the supply chain, and in relation to other concurrent challenges (such as meeting the growing demand for food and fibre). This includes reducing barriers to adaptation, while at the same time building adaptive capacity.

Further references and resources can be located at the end of this chapter.

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Adaptation strategies

Short-term adaptation strategies – implementation of 'best practice'.

The simplest adaptation options are closely associated with existing 'best practice' and good natural resource management, and do not require farmers to make radical changes to their operations and industries in the near term. These are the use of more adaptable cultivars and a range of cultural practices that enable growers to maintain current production in current locations – i.e. adapt to the 'new' climate in the current location.

Adaptation strategies will have different challenges, opportunities, costs and risks for different crops, but could include (and are not limited to):

- Variety selection and diversification to take advantage of changes in climate conditions or manage risk of extreme events – consider rootstock selection and use of drought tolerant or 'climate ready' varieties. For many perennial crops, plan for earlier harvest times and address marketing issues such as access and timing;
- Irrigation efficiency – consider identifying less water-intensive production options, developing better water delivery technologies, implementing water markets and water-sharing and increase water storage capacity to better meet irrigation requirements;
- Soil and water conservation methods become even more important as climates fluctuate more and extreme events become more frequent - consider careful management of the soil moisture profile, irrigation scheduling based on soil moisture monitoring devices and landscaping to reduce erosion during heavy falls;
- Biosecurity, quarantine, monitoring and control measures can be strengthened to control the spread of pests, weeds and diseases under a warming climate - consider providing habitat for increasing beneficial insects;
- Physical/structural measures - consider canopy protection using netting in fruit orchards to increase protection from heat stress, frosts and hail; evaporative cooling as a technique for reducing sunburn; and/or shade nets and some commercial kaolin-based coatings for repeling pests (shade nets have the added benefit of preventing hail damage);
- Chemical options - consider chemical dormancy breakers to help counteract the lack of suitable chilling hours;
- Property design - consider modifying the management of the inter-row environment, to take into account potential frost risk and the impacts of high rainfall events such as erosion and salinity, as well as integration of biocontrol techniques (e.g. host-free zones) to reduce increased use of pesticides; and
- Forecasting and planning – consider tools for improving medium and long-term forecasting of seasonal conditions. Undertake risk assessment to assess sustainability in more marginal areas (e.g. chilling requirements, increased frost risk, increased quality problems).

These options can, and should, be prioritised as part of a 'no regrets' or win–win strategy for agriculture because they will provide immediate and ongoing benefits, such as productivity benefits and market access, as well as preparing the sector for climate change.

In addition, monitoring and evaluation systems are needed to continue to track changes in climate, further impacts and the effectiveness/refinement of adaptation measures. Closer collaboration between policy makers, managers, researchers, extension agencies and growers will ensure timely inclusion of climate information as it becomes available.

Further references and resources can be located at the end of this chapter.

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Medium term adaptation strategies – understanding and managing climate variability

In the short to medium term, existing strategies for dealing with climate variability, as above, will help to plan for, and deal with, extreme events (droughts, floods, fire, hail, etc.).

None of the existing tools used in managing climate variability have been designed specifically with any horticultural industry or application in mind. Most of these have been developed for the management of rainfall variability only and do not address temperature variability.

Currently, climate science does not adequately addresses the lead-time and season length requirements of horticultural crops, nor crop-specific data, such as thresholds for chilling hours, heat stress days, etc. For example, there are no forecast systems based on the Southern Oscillation Index (SOI) and Sea Surface temperatures (SST) which have been extensively tested for longer lead-times and shorter seasons.

The combination of long season (3 months) and short lead-time (zero), which are appropriate for other agricultural industries, is a significant constraint to the use of forecasting tools in horticulture, where a much shorter season length (several weeks to one month) and a much longer lead-time (3 to 4 months), would be much more useful. Given a sound forecast system that meets the requirements of the industry the appropriate tools can then be produced.

Existing tools for managing climate variability in agriculture include:

- POAMA (Predictive Ocean Atmosphere Model for Australia) http://poama.bom.gov.au/operational_products.shtml - Registered Users can access additional information on (click on the 'Request Login' to gain access).
  The Predictive Ocean Atmosphere Model for Australia (POAMA) is a seasonal to inter-annual seasonal forecast system based on a coupled ocean/atmosphere model.
- Climate Kelpie – round up of climate tools for Australian farmers http://www.climatekelpie.com.au
- Bureau of Meteorology (BOM) – Seasonal Temperature Outlook http://www.bom.gov.au/climate/
- LongPaddock http://www.longpaddock.qld.gov.au/
- Madden Julian Oscillation (MJO) http://www.bom.gov.au/climate/tropnote/tropnote.shtml
- Climate Dogs http://www.depi.vic.gov.au/agriculture-and-food/farm-management/weather-and-climate/understanding-weather-and-climate/the-climatedogs-the-four-drivers-that-influence-victoriaas-climate
- Rainman StreamFlow version 4.3 http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/cropping-efficiency/rainman
- Southern Oscillation Index (SOI) http://www.bom.gov.au/climate/glossary/soi.shtml or for latest values see http://www.longpaddock.qld.gov.au/seasonalclimateoutlook/southernoscillationindex/index.php or seasonal outlook see http://www.longpaddock.qld.gov.au/SeasonalClimateOutlook/RainfallProbability/index.html
- Sea Surface Temperatures (SST) http://www.longpaddock.qld.gov.au/seasonalclimateoutlook/seasurfacetemperature/index.php
- SILO climate data (available through paid licensing agreement) http://www.longpaddock.qld.gov.au/silo/

Further references and resources can be located at the end of this chapter.

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Climate Dogs are a series of short, clever and humorous animations that capture key climate science messages and package them in a way that is relevant to farmers. Through stories about four 'climate dogs', the animations discuss key drivers of Victoria's weather patterns and seasonal variability: El Niño Southern Oscillation, Indian Ocean Dipole, Subtropical Ridge and Southern Annular Mode. The four sheep dogs that round up Victoria's rainfall are ENSO, INDY, Ridgy and Sam. Some of the Climate Dogs have application to other regions of Australia as well.

Website: http://www.depi.vic.gov.au/agriculture-and-food/farm-management/weather-and-climate/understanding-weather-and-climate/the-climatedogs-the-four-drivers-that-influence-victoriaas-climate

The Managing Climate Variability (MCV) program is a national climate variability research initiative. To date there have been two horticulture specific projects established through collaboration with MCV:

- Australian horticulture's response to climate change and climate variability (AH06019); and
- Critical thresholds ('tipping points') and climate change impacts/adaptation in horticulture (HG08037).

See also http://www.managingclimate.gov.au

Long-term adaptation strategies – transformational change

As more extreme climate change is observed, the benefits obtained from each major type of adaptation are likely to plateau, as Figure 2 indicates. This means that there are likely to be limits to the effectiveness of incremental adaptations and that, at some point, a major change or transformational adaptation will be called for.

Examples of transformational adaptation could include restructuring of a business (e.g. into protected cropping or adoption of substantial off-farm work to increase income), shifting location (e.g. large financial investment into new land in a more favourable regions), and/or change to production system (e.g. crop type or production system from conventional to organic).

Common to all change, transformational adaptation to climate change can involve some significant costs (although this should not be considered alongside opportunity costs, i.e. that which emerges when action is not taken) and requires a higher level of adaptive capacity than incremental or systems-scale adaptation due to the greater risks and complexity arising from the change.

Further references and resources can be located at the end of this chapter.

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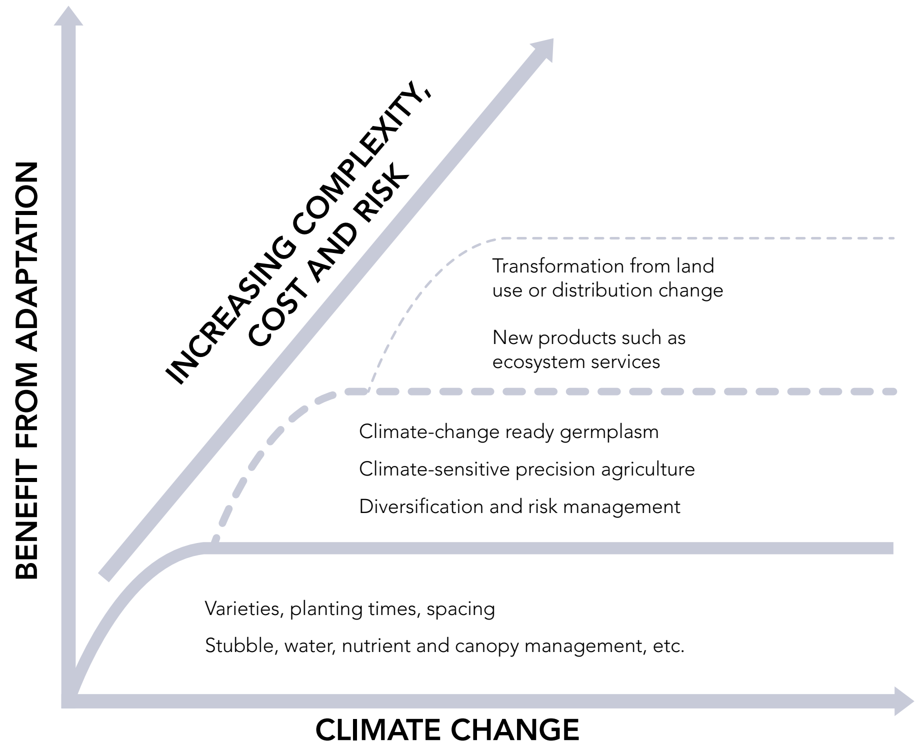

Figure 2: The potential benefit from different levels of adaptation with increasing climate change from incremental, within-system responses, to system-level changes to transformational changes. Source: Stokes, & Howden, M. (2011)

A note on mitigation

It is vital that adaptation responses are integrated with mitigation as the two are intimately linked. Mitigation is a process whereby the sources of greenhouse gas emissions are reduced, and/or carbon sinks are created or enhanced. Options for mitigation in horticultural production have been addressed in Chapter 8 – Energy & greenhouse gas management.

The horticulture industry is extremely susceptible to the impacts of climate change/variability and, as a result, needs to be supporting the need for mitigation and reduction of emissions to reduce the impacts of climate change at the same time as implementing adaptation approaches (where appropriate/needed).

This involves ensuring that adaptations do not increase greenhouse gas emissions, so making the underlying cause worse – and, similarly, that mitigation options do not undermine adaptation efforts. For example, adopting management practices that improve the efficiency of nitrogen use can generate benefits for farm profitability, while also reducing greenhouse impacts and improving environmental sustainability.

Continual improvement of horticulture's response to the challenges of climate change and climate variability.

Flexibility has been the key to adaptation in horticulture to date, and is likely to continue to be an important component of adaptation strategies as climates continue to change. Growers have been able to manage climate variability reasonably well, although major improvements could be made if tools to assist with the management of climate variability, both temperature and rainfall, and extreme events were designed specifically with the needs of horticultural growers and industries in mind. This includes the development of capacity along with the provision of appropriate data and decision support tools to allow the rapid (and cheap) assessment of climate risk and the identification of possible adaptation measures, and estimates of associated costs.

It will also be important to identify those countries/regions that currently export product to Australia, which will be significantly impacted by rising temperatures along with those that will become more competitive on the Australian market because of favourable impacts as a result of further changes to the world's climate.

This will ensure both the long-term viability and sustainability of the sector, and continued availability to consumers of fresh and health-giving horticultural outputs.

Further references and resources can be located at the end of this chapter.

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Climate adaptation

References and further reading

ABS (2012) Completing the Picture - Environmental Accounting in Practice, Australian Bureau of Statistics, Canberra, ACT.
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4628.0.55.001main+features30May+2012#anchor2

Amati, M. (2013) Understanding the carbon and pollution mitigation potential of Australia's urban forest (HAL Project Number: NY11002). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Brown, G. (2011) Investigating and overcoming negative effects of global warming on cherry dormancy (HAL Project Number: CY09012). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Brunt, C (2012) Cherry cultivar selection: chill hours and climate change (HAL Project Number: CY11010). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Carey, D.; White, N.; & Deuter, P. (2012) Horticulture and Climate Q – improving on our understanding of climate change, vulnerability, adaptation and risk management responses, in major horticultural industries and regions of Queensland. Horticulture and Forestry Science Department of Fisheries and Forestry Queensland.

Cobon, D.; Stone, G.; Carter, J.; Scanlan, J.; Toombs, N.; Zhang, X.; Willcocks, J.; & McKeon, G. (2009) The climate change risk management matrix for the grazing industry of northern Australia. CSIRO Publishing.

Chen, D. (2013) Greening City - Mitigate Heat Stress with Urban Vegetation (HAL Project Number: NY11013). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Corner, D. (2011) Positioning the Queensland Cut Flower Industry to Strategically Respond to the Impact of Climate Change (HAL Project Number: FL09006). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

CSIRO (2011) Climate Change: Science and Solutions for Australia, CSIRO.
http://www.csiro.au/Outcomes/Climate/Climate-Change-Book.aspx

DIICCSRTE (2013) Climate Adaptation Outlook: A proposed national adaptation assessment framework. Australian Government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.
http://www.climatechange.gov.au/climate-change/adapting-climate-change/climate-adaptation-outlook)

DIICCSRTE (2013) Climate Change Adaptation Good Practice – Case Study: South Australian Integrated Climate Change Adaptation. Australian Government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Deuter, P. pers comms (2014) Senior Principal Horticulturist, Horticulture and Forestry Science, Department of Agriculture, Fisheries and Forestry (Queensland).

Deuter, P. (2011) Horticulture contribution to Managing Climate Variability Program - critical thresholds project (HAL Project Number: HG08037).
http://www.horticulture.com.au/areas_of_Investment/Environment/Climate/Climate_critical_thresholds.asp and http://www.managingclimate.gov.au/research/completed-projects/critical-thresholds-tipping-points-and-climate-change-impacts-adaptation-in-horticulture/

Deuter, P. (2008) Defining the impacts of climate change on horticulture in Australia. Chapter of the Garnaut Climate Change Review. Department of Primary Industries and Fisheries, Queensland.
http://www.garnautreview.org.au/CA25734E0016A131/WebObj/01-GHorticulture/$File/01-G%20Horticulture.pdf

Dwyer, E.; Gunner, E. & Sheperd, K. (2009) The Changing Climate: Impacts and adaptation options for South Australian primary producers. Primary Industries and Resources, SA.

Gaunaut Climate Change Review – multiple reports (2011).
www.garnautreview.org.au

HAL. (2010) Climate Change: Managing Variability and Carbon. Horticulture Australia Ltd.
http://ausveg.businesscatalyst.com/rnd/fact%20sheets/Climate%20Change%20and%20Managing%20Carbon.pdf

Howe, T. (2012) Carbon footprinting and labelling – understanding the language, trends and tools (HAL Project Number: HG10045). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

IPCC (2013) Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
http://www.ipcc.ch

McKenzie, R. (2011) First steps in a response to climate change and climate variability: desktop study (HAL Project Number: AP09019). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Pearson, L. and Langridge, J. (2008) 'Climate change vulnerability assessment: Review of agricultural productivity' CSIRO Climate Adaptation Flagship Working paper No.1. Web-ref
http://www.csiro.au/resources/CAF-Working-Papers

Putland, D. & Deuter, P. (2011) The effects of high temperatures on vegetable production and the rapid assessment of climate risk in agriculture. Proceedings of the 2011 APEC Workshop on Collaboration on the Promotion of Indigenous Vegetables for Coping with Climate Change and Food Security, pg 45-62. APEC Agricultural Technical Cooperation Working Group, 21-24 November 2011, Chinese Taipei.

Rickards, L. & Howden, M. (2012) Transformational adaptation: agriculture and climate change. CSIRO Publishing. Crop and Pasture Science 63(3) 240-250.
http://www.publish.csiro.au/paper/CP11172.htm

Roche, M. (2013) Adaptation of warm-season turf grasses for tropical Australia (HAL Project Number: TU09001). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Rogers, G. (2013) Understanding and managing impacts of climate change and variability on vegetable industry productivity and profits (HAL Project Number: VG12041). Final report published by Horticulture Australia Ltd, Sydney, NSW.
www.horticulture.com.au

Stokes, CJ and Howden, SM. (2011) Adapting agriculture to climate change, Chapter 7 of Climate Change: Science and Solutions for Australia, CSIRO.
http://www.publish.csiro.au/?act=view_file&file_id=CSIRO_CC_Chapter%207.pdf

Stokes CJ and Howden SM (eds) (2010) Adapting Agriculture to Climate Change: Preparing Australian Agriculture, Forestry and Fisheries.

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