







A Farmer's Guide to Climate Change in Queensland

QFF QUEENSLAND FARMERS' FEDERATION

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2008

Foreword

The topic of climate change has continued to be ramped up with a move from the "change the light globe" scenario to harsher realities that reducing green house emissions will come at a significant cost to business and consumers. Agriculture has been left out in the cold to some extent, yet is probably the industry to be most affected by climate change.

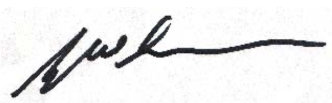
Australians have been very fortunate over the years in that they have not had to face food shortages, other than for some brief periods of rationing during the war. However, with agriculture this could well change in coming decades as a changing climate adds to the challenges and risks farmers face in terms of higher temperatures, lower rainfall, more extreme events and more uncertainty. Australian farmers have a proud record of managing one of the most variable climates in the world, and the challenges of the future are not beyond us. But, preparing for the future means understanding what that future might mean, and making the adjustments now to minimise risk and maximise opportunity.

That is very much what this report is about, and the climate change adaptation project undertaken by QFF in 2007-8 aimed to kick-start.

But, while industry needs to play its part in preparing to adapt to climate change, there is a broader agenda. Australia needs to start to develop an overarching food strategy under which policies can be developed when dealing with climate change, water policy and other regulatory issues adding to the costs of farming. Development of an appropriate strategy would ultimately need to involve all levels of government. Similar consideration must be given to ensuring that our fibre and foliage industries also remain viable.

While it is probable that agriculture will not be included in the first round of an emissions trading scheme, there will still be significant impacts on input costs which will need to be passed on if farmers are to have any hope of remaining viable. There may be alternatives to actual inclusion in an ETS, such as recognising that the good farm practices that have been or are being developed as adaptations to climate change will also in many cases provide mitigation outcomes.

I wish to thank the many people involved in producing this report, which represents a marvellous and unique collaboration between climate experts, scientists, rural industry bodies and producers. The greatest lesson of this project and this report is that only by sharing what we know can we build a better future for Australian agriculture.



Gary Sansom
President
Queensland Farmers' Federation

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Acknowledgements

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QFF wishes to thank the members of the Expert Scientific Panel who participated in this project:

Gary Sansom (President QFF) (Chair)
Professor Timothy Reeves (Facilitator)
Professor Roger Stone (University of Southern Queensland)
Dr Jerry Maroulis (University of Southern Queensland)
Professor Peter Grace (Queensland University of Technology)
Colin Creighton (Land & Water Australia)
David McRae (Queensland Climate Change Centre of Excellence)
Peter Deuter (Queensland Dept of Primary Industries & Fisheries)
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Stephen Carroll (Australian Bankers Association)

Executive Summary

Adaptation to climate change is one of the biggest challenges facing Australian agriculture in the next 20 to 30 years. Like all changes, a changing climate brings both risks and opportunities. Those who better understand the nature and implications of the change can adapt more effectively to avoid the risks and seize the opportunities.

As part of the Australian Government's National Agriculture and Climate Change Action Plan, Queensland Farmers' Federation (QFF) undertook an industry-led strategic climate change project focused on better enabling intensive agricultural industries in Queensland to identify and manage climate change risk. The industries involved in the project included cropping (sugar cane and cotton), horticulture (tree, perennial and seasonal crops, nursery and flower production) and intensive livestock (dairy, aquaculture and chicken meat).

This report documents the key findings of the QFF project, contributing a new level of understanding to climate change projections in Queensland, energy efficiency measurement in intensive agriculture and the use of industry Farm Management Systems to manage risk and assist producers respond to climate change.

One of the key findings of this report has been the need to more closely align climate science research with the decision mapping needs of farm managers. Industry workshops conducted during this project identified the need for more disaggregated climate data and more accurate climate parameters to match weather events that may impact intensive farming operations.

As part of this project, the University of Southern Queensland generated detailed regional climate change modelling for selected regional centres. Results from the modelling process have been presented by comparing the per cent change of the projected climate in 2030 to the average climate across the period from 1961 to 1990. This approach has arguably produced the most accurate and regionally specific rainfall, temperature and solar radiation projections for Queensland to date.

Results from the use of the five best climate models (as tested against Queensland conditions, particularly modelling the impact of ENSO), show that monthly weather patterns are likely to shift sufficiently in future years, defining a new summer wet season from January to March rather than the traditional December to February. All results in this project are aligned to these new seasonal quarters.

Results from climate modelling of annual rainfall change in Queensland by 2030 show a general decrease in mean rainfall relative to the 1961 to 1990 baseline throughout the majority of the state of around -10 to -50 millimetres, although this decrease is less (or even a slight increase) in far northern regions and central inland regions. Summer rainfall increases from 0 to 50 millimetres across the majority of Queensland, but the rest of the year is drier. The greatest reductions (see table 1 page 14) are predicted to occur in coastal regions in the drier months. Rainfall is also projected to occur in less frequent but more intensive rainfall events. Increases in maximum and minimum temperatures and solar radiation will most likely result in increased evaporation rates, thus further decreasing water availability.

In general, the climate projections in this report extend the findings of recently published projections such as the Queensland Government's (2008) *Climate Change in Queensland: What the Science is Telling us*. However, farmers require this type of climate change data to be disaggregated and presented in a way that helps farm-level decision making. Considerable progress was made in this direction during the course of this project, as evidenced by the material in the following pages.

Results from research into energy use in intensive agricultural industries has shown that energy use within and between intensive agricultural industries is highly variable and that significant opportunities exist to increase energy efficiency. Work conducted by the National Centre for

Engineering in Agriculture (NCEA) has identified improvements of 30 - 40 per cent energy savings through improved pump and system hydraulic performance and tractor operations. Similarly, 10 to 20 per cent energy savings have been identified through the adoption of alternative farming systems. In this way, the quantification of energy use in various intensive agricultural industries in this report is a significant step towards establishing a framework and methodology for a detailed energy emissions auditing process in the future.

The various industry action plans presented in this report show the diversity of the impact of projected climate change across commodities and regions. Industry based Farm Management Systems (FMS) continue to provide a highly effective risk management framework from which to manage producers' climate change response. Combining information on adaption and mitigation with the support of appropriate decision making tools such as FMS's will maximise the effectiveness of the future climate change response in intensive agricultural industries in Queensland. Indeed, continuous updating of climate information and tools in industry-led programs could provide the crucial extension 'missing link' between the scientific community and producers.

A key challenge for the industries involved in this project, and the Expert Scientific Panel, was to identify the 'tipping points' and critical climate factors that will significantly impact on agricultural production decisions. More information on these critical climate factors is still required to inform both short-term production decisions, and longer term decisions on investment, growth and continued viability of particular crops and cropping systems in particular regions.

Nursery Industry examples of Key Tipping Points

Nursery Production - Tipping Point

Major tipping points for Nursery growers production are the limited access to reliable water supplies for producers and end users.

Production Nursery Specifics

Irrigation water accessed from ground water, surface flow, and on-farm storage facilities will be affected by changing rainfall patterns across Queensland. Evidence from the recent drought is South-East Queensland suggest that storage and access to water for irrigation is likely to be a limiting factor for the production nursery industry in the future.

End User Specifics

- Production nursery supplying urban horticulture – major tipping point is the limited access to reliable water supplies for urban streetscapes and home gardens (potable, ground, recycled and rainfall).
- Production nursery supplying fruit & vegetable producers – major tipping point is the limited access to reliable water supplies for fruit & vegetable producers (supplementary water, ground and rainfall).
- Production nursery supplying revegetation/mine rehabilitation – major tipping point is the limited access to reliable water supplies for the environment generally.
- Production nursery supplying forestry/timber – major tipping point is the limited access to reliable water supplies for our plantations and environment generally.

Future climate modelling

It is recommended that:

- the methodology and results outlined in this report be further developed, refined and where appropriate, used to inform the emerging climate change discussion and the development of decision support tools;
- the “baseline” period of 1961 to 1990 be reviewed to enable greater comparison between “future change” and the weather conditions that have been experienced in more recent times;
- data associated with climate projection be further refined to identify additional climate parameters such as stream flow, runoff yields, evaporation, rainfall intensities, and maximum and minimum temperatures.

Future work could include the use of detailed, regionally specific projections to inform future water resource planning, and the revision of the Queensland Government’s *Climate Change in Queensland: What the science is telling us* (Queensland Government 2008).

Energy efficiency in intensive agricultural industries

It is recommended that:

- any energy auditing tools for future use in intensive agricultural industries first focus on energy use in irrigation systems, as this consumes a considerable proportion of on-farm energy cost;
- future irrigation energy audits are combined with water efficiency audits to provide a combined service to interested farmers;
- considerable research on energy use on farms is undertaken to benchmark energy efficiency for a variety of different agricultural equipment.

Industry Farm Management Systems

It is recommended that:

- additional resources be provided to assist the intensive agricultural industries in Queensland develop and enhance adaptation, mitigation and communication strategies;
- assessment of risk and the delivery of assistance to producers be achieved through incorporating climate change issues into existing Farm Management Systems;
- both industry and government continue to strengthen the connection between industry Farm Management Systems and climate change response;
- additional research, development and extension needs to be undertaken by both industry and government in areas where adaption and emission reductions are hindered by a lack of knowledge.

Introduction

This report is based on the results from the Queensland Farmers' Federation (QFF) project titled *Improving the Capacity of Queensland Intensive Agricultural to Manage Climate Change* which was funded by the Department of Agriculture Forestry and Fisheries (DAFF) in 2007-2008.

QFF brings together 10 of Queensland's peak rural industry organisations who collectively represent more than 13,000 primary producers across the state. The membership of QFF during this project included:

- Canegrowers;
- Growcom (horticulture);
- Queensland Dairyfarmers' Organisation;
- Cotton Australia;
- Nursery & Garden Industry Queensland;
- Queensland Chicken Growers' Association;
- Australian Prawn Farmers' Association;
- Queensland Pork Producers Inc;
- Queensland Chicken Meat Council;
- Flower Association of Queensland.

Climate change continues to grow as the global issue of highest importance. There is an emerging consensus among the international scientific community that emissions from human related activities have already and will continue to cause the earth to warm and weather patterns to change (IPCC 2007). The projected changes in climate are likely to cause a variety of biophysical, environmental, social and economic impacts on nations throughout the world (Garnaut Climate Change Review 2008; Stern 2006, 2008).

The impact of climate change in Australia is most likely to be greatest in sectors of the economy that are heavily dependent on favourable climate conditions. Intensive agriculture in Queensland is one such sector. Research by ABARE (2007) suggests that agriculture in Australia will bear the biggest impact of any nation as a result of climate change. Queensland industries (such as beef and sugar) are likely to be some of the most significantly affected. (ABARE 2007).

At the initiation of the project, participants recognised the variable nature of Australia's climate and so agreed it would be constructive to examine climate change scenarios in relation to recent climate experiences. The aim here was to provide farmers with key measures of temperature and rainfall and identify trends that might already be in motion. This could also provide an opportunity perspective for climate scientists can demonstrate how farmers are already dealing with climate challenges.

In this way, this report addresses the projected impact of climate change on intensive agricultural industries in Queensland, helping bridge the gap between science, government and industry.

This has been achieved by refining existing climate forecasts into more regionally specific and usable climate projections, measuring energy use in intensive agricultural industries, advancing industry understanding of risks, opportunities and responses to climate change and strengthening the connection between industry Farm Management Systems (FMS) and the management of risk associated with climate change.

The QFF climate change project gathered together an extensive body of knowledge on Queensland's intensive agriculture industries and climate change, combining outputs from cross-disciplinary groups of experts with grower workshops and regular industry steering committee meetings.

Intensive agricultural industries in Queensland are now in a much better position to adapt to climate change as a result of participating in this project.

Queensland's future climate

Past climate modelling

Modelling climate change is a complex and emerging science. The many variables and assumptions involved in climate change modelling mean that predictions are often expressed as a range of possible change, rather than an exact number or percentage change (CSIRO & Australian Bureau of Meteorology 2007; IPCC 2007). Furthermore, no one accepted model for projecting climate change exists. However, modelling results from 23 different Global Circulation Models from the accepted world expert body on climate change science the International Panel of Climate Change (IPCC 2007) provides typically a good indication of the earth's future climate results from different scenarios, are averaged to predict how climate might change in the future but there is wide debate about "a better selection" of models.

The difficulties associated with climate change modelling means that many model outputs are unable to supply precise information and are frequently not optimised to project change for small regional areas. Furthermore, due to the large number of different models and the many variables involved, such as the future level of atmospheric carbon dioxide (high, medium or low), outputs are commonly imprecise with a wide range of possible change. Figure 1 shows the large range of predicted change for temperature across different emissions scenarios and time periods based on the averaged results of different climate models. The most recent climate projections for Queensland for three time frames and three emission scenarios are contained in the Queensland Government (2008) publication *Climate Change in Queensland: What the science is telling us*. A sample of the annual average temperature information can be seen in Figure 1.

The difficulty of producing detailed regional information for future climate change hinders producers' capacity to understand and manage risk associated with long term climatic change. In response, one of the key aims of the QFF climate change project was to identify more detailed regionally and seasonally specific climate change data and to present this data within a regionally specific risk management framework.

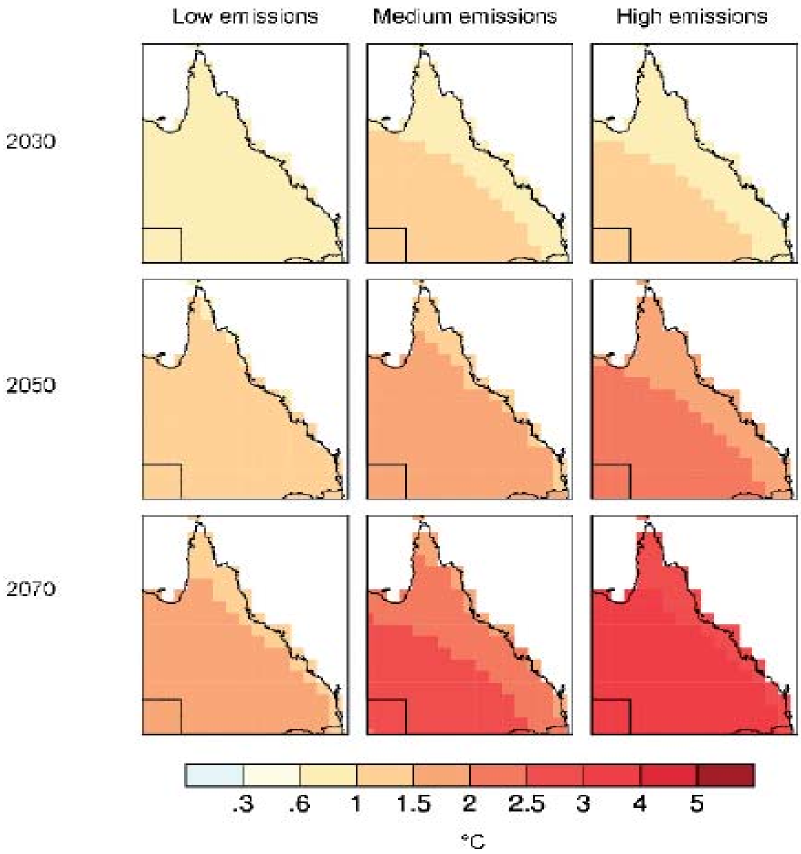


Figure 1: Best estimate (50th percentile) of annual Queensland temperature change showing the large variety of modelling possibilities
Source: CSIRO and Bureau of Meteorology (2008) in Queensland Government (2008) p13.

Climate Change Predictions for Intensive Agricultural regions

A key component of the QFF project was to develop "fresh" climate projections specifically for the intensive agriculture regions of Queensland. To achieve this researchers from University of Southern Queensland (USQ) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) compared the capacity of the 23 IPCC models to replicate the climatic patterns and trends experienced in Queensland over recent decades. In particular, the ability of different models to predict climatic events such as rainfall, El Nino and La Nina weather patterns was closely examined. Using this method, the 23 Global Circulation Models in the IPCC (2007) report were systematically reduced to identify the five most appropriate models for use in Queensland's climatic context. A medium emissions scenario was then used with these models to generate a new series of climate change projections for rainfall likelihoods, maximum/minimum temperatures and solar radiation levels in Queensland.

It was agreed by, the Expert Panel in the QFF project that this approach would produce much more accurate results than the more aggregate 15 or 23 model outputs used in earlier studies. In this way it is recognised by the Australian scientific community that an improvement of current climate change projections are needed (Professor Roger Stone, pers. comm, August 2008). This is reflected in the statement by the Queensland Government (2008) that climate change projections for Queensland will be updated in late 2008.

In the QFF climate change project, detailed regional information was also generated for selected regional centres. Results from the modelling process have been presented by comparing the percentage change of the projected climate in 2030 to the average climate across the period from 1961 to 1990. This approach has arguably produced the most accurate and regionally specific rainfall, temperature and solar radiation projections for Queensland to date.

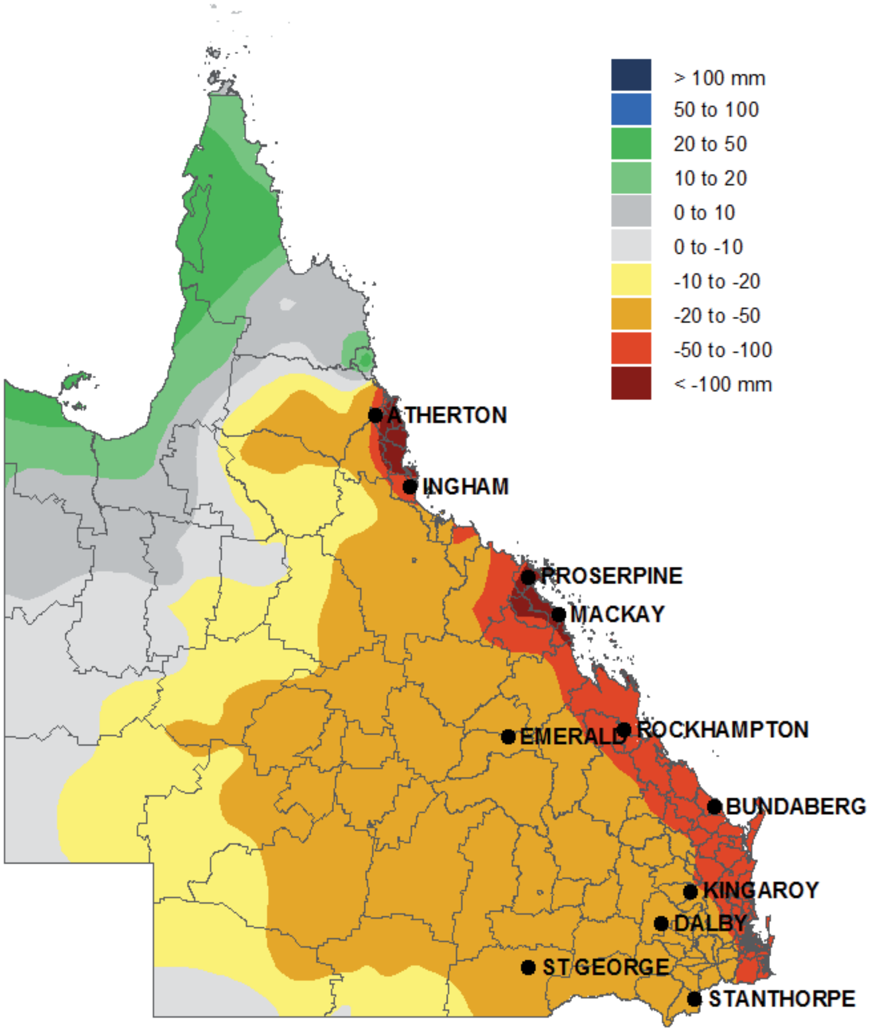


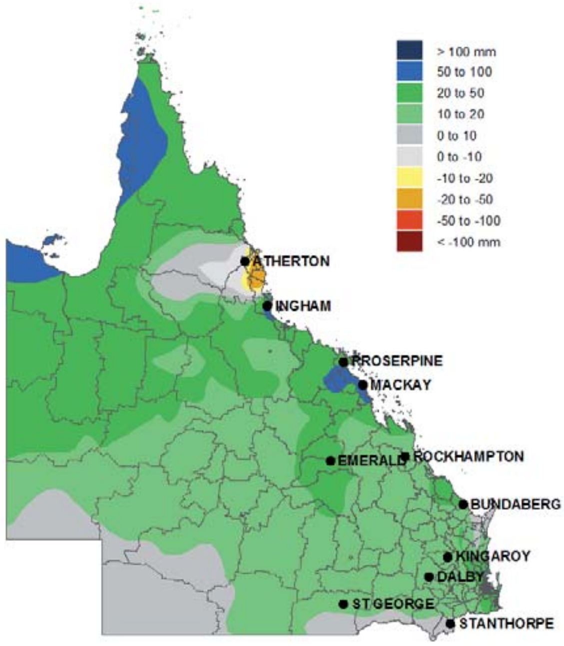
Figure 2: Annual 2030 rainfall change in Queensland relative to the 1961-1990 baseline

Projected rainfall changes in Queensland's future climate

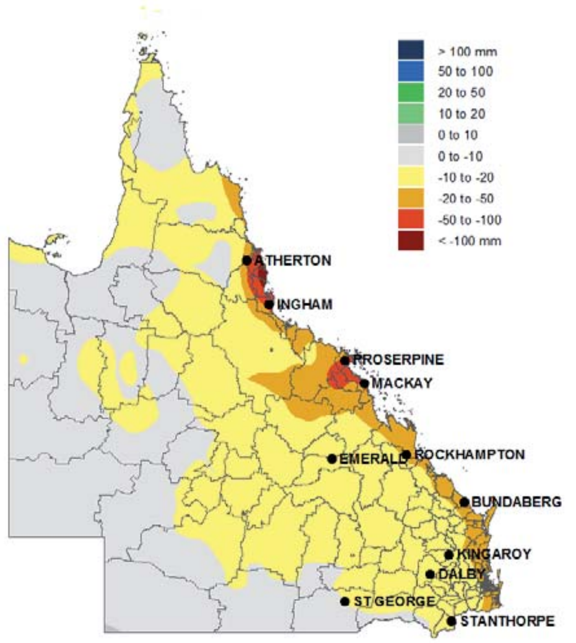
An important "finding" of the "five best models" approach has been the revelation that it is now more appropriate to define changes in summer rainfall as those occurring between January and March rather than from December to February. All results in this project are aligned to these new periods of analysis.

Results from climate modelling of annual rainfall change in Queensland by 2030 also show a general decrease in rainfall relative to the 1961 to 1990 baseline throughout the majority of the state of around minus 20 to -100 millimetres. However as seen in Figure 2, this decrease is less in far northern regions and far wester regions. On the other hand results show some significant reductions for coastal areas especially around the important sugar production region of Mackay.

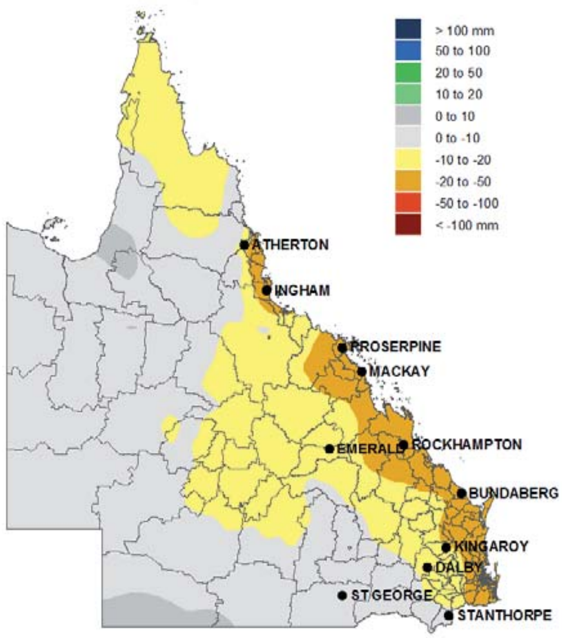
The seasonal breakdown of annual rainfall change provides more detailed information on projected rainfall changes in Queensland by 2030. As seen in Figure 3, results show that summer rainfall increases from 0 to 50 millimetres across the majority of Queensland. However, Figure 3 results also show that the rest of the year is likely to be very dry with the greatest reductions (minus 20 to minus 50 mm) projected to occur in coastal regions in winter months. Importantly, from other studies there is a consensus that this rainfall is also projected to occur in less frequent but more intensive rainfall patterns. However, it is important to recognise that annual rainfall is generally higher in coastal regions and therefore the projected reductions are not as significant as they would be if they were to occur further inland.



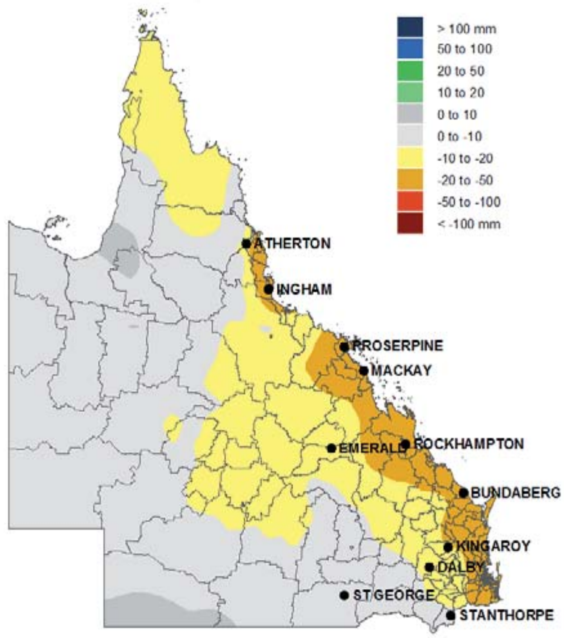
Rainfall change by 2030 for the period January, February, March



Rainfall change by 2030 for the period April, May, June.



Rainfall change by 2030 for the period July, August, September.



Rainfall change by 2030 for the period October, November , December.

Figure 3: Seasonal rainfall change in Queensland relative to the 1961-1990 baseline

Finally, while rainfall is projected to decline, increases in maximum and minimum temperatures and solar radiation will most likely result in increased evaporation rates further decreasing water availability. These issues will be discussed later in this section. More details of rainfall change can be seen in Table 1.

Town	JFM	AMJ	JAS	OND	ANNUAL
Atherton	-10.9 mm	-21.2 mm	-10.9 mm	-12.4 mm	-56.2 mm
Bundaberg	23.2 mm	-25.1 mm	-20.6 mm	-21.7 mm	-69.1 mm
Dalby	13.9mm	-12.9 mm	-19.0 mm	-12.6 mm	-34.5 mm
Emerald	25.6 mm	-16.4 mm	-17.4 mm	-15.6 mm	-34.7 mm
Gatton	17.8 mm	-16.0 mm	-17.0 mm	-14.3 mm	-37.5 mm
Ingham	76.6 mm	-71.6 mm	-23.5 mm	-31.1 mm	-69.0 mm
Kingaroy	14.0 mm	-12.7 mm	-18.4 mm	-17.5 mm	-40.0 mm
Lismore	10.6 mm	-31.7 mm	-15.1 mm	-18.4 mm	-67.1 mm
Mackay	50.2 mm	-60.3 mm	-15.2 mm	-36.9 mm	-122.1 mm
Proserpine	51.3 mm	-62.3 mm	-15.8 mm	-34.7 mm	-123.1 mm
Rockhampton	15.3 mm	-21.1 mm	-12.9 mm	-26.3 mm	-65.0 mm
St George	12.8 mm	-10.2 mm	-16.4 mm	-3.9 mm	-28.5 mm
Stanthorpe	6.2 mm	-14.7 mm	-15.0 mm	-5.1 mm	-31.9 mm

Table 1: Projected seasonal rainfall change in key Queensland regional centres relative to 1961 to the 1990 baseline

The results in Table 1 identify the quantum of the projected climatic trend of rainfall increases in summer and decreases in autumn, winter and spring. These results advance climate modelling in Queensland to a new level of detail, allowing primary producers to see projected rainfall change in millimetres at a regional scale rather than a range of possible change expressed at a percentage of the baseline period. The project Expert Panel concluded it was appropriate to use 2030 scenarios that showed wetter but shorter summer wet seasons followed by a much drier remaining nine months. The above results are tabulated this way to help farmers gauge the seasonal rainfall changes they may have to deal with by 2030.

At the conclusion of the project, the project team became aware of other detailed studies being conducted covering overlapping issues and regions, especially those addressing water availability in the Murray-Darling Basin. It is expected that in the future, scientists, water users and other stakeholders will reconcile these studies and refine the rainfall/runoff scenarios to assist planners and decision makers in these regions.

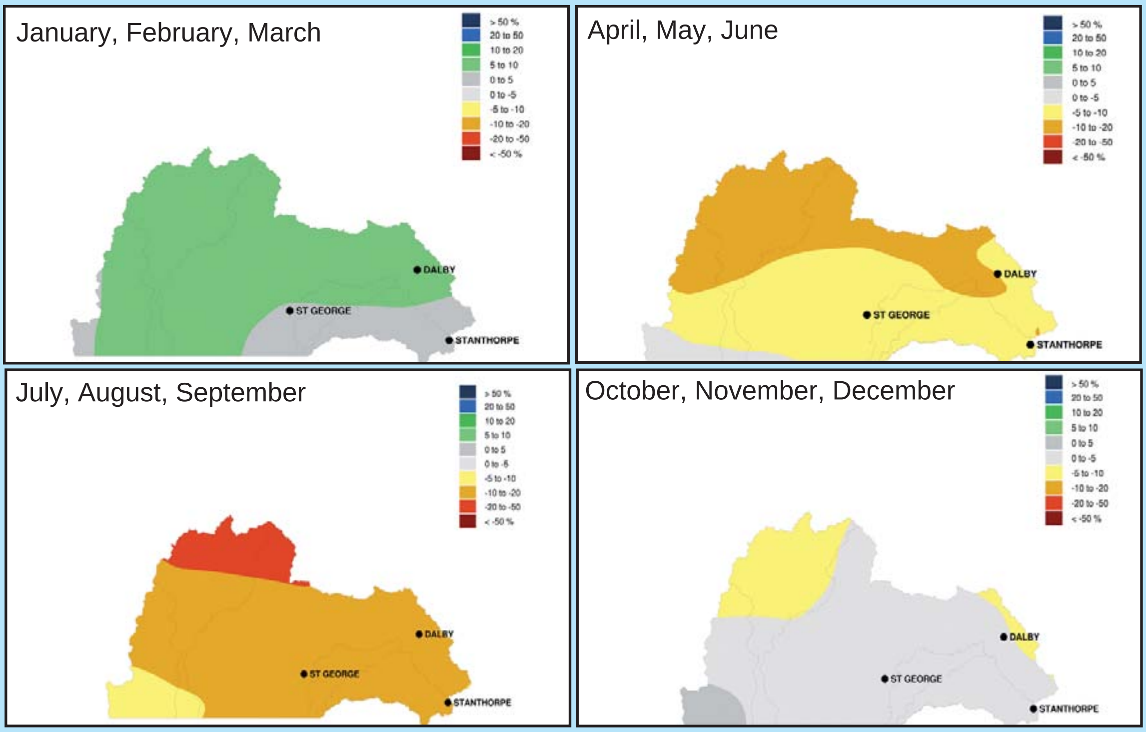
Projected temperature changes in Queensland's future climate

Results from selected climate models show that average temperature levels are projected to further increase in coming years. Overall the warming trend seen in Figure 4 is believed to be weaker in coastal and far northern regions (.5 to 1 degree) but stronger in inland regions (1.5 degrees). The seasonal breakdown of this trend (see Figure 5) shows that inland warming is likely to slightly lessen in summer but increase throughout the rest of the year.

The impact of climate change in intensive industries will vary considerably depending upon the production region. For the Queensland Natural Resource Management region known as the Queensland Murray-Darling Basin (see below), reductions in mean rainfall by 10 to 30 per cent in key winter growing periods are likely by 2030. While appearing to be a drastic reduction, this change is relative to the seasonal pattern of rainfall and is therefore lessened by the significant contribution of summer rainfall to streamflow for irrigation purposes.

In this way, results suggest that some potential for recharge in the river/irrigation systems exists over the January to March period, but little opportunity is likely to exist throughout the remainder of the year. In the past, the October to March period has been identified as the main recharge period for the Queensland Murray Darling Basin. Combining results from this study with current understanding of rainfall in this region suggest a likely overall reduction in water for irrigation for the total spring to summer period.

In other words, projected rainfall increases from January to March in this region are unlikely to be sufficient to compensate for rainfall reductions in early summer, autumn, winter and spring. This projected reduction has potentially major implications for grain/cotton production in this region.



Box 2: Regional specific rainfall (percent) change in the Queensland Murray Darling Basin

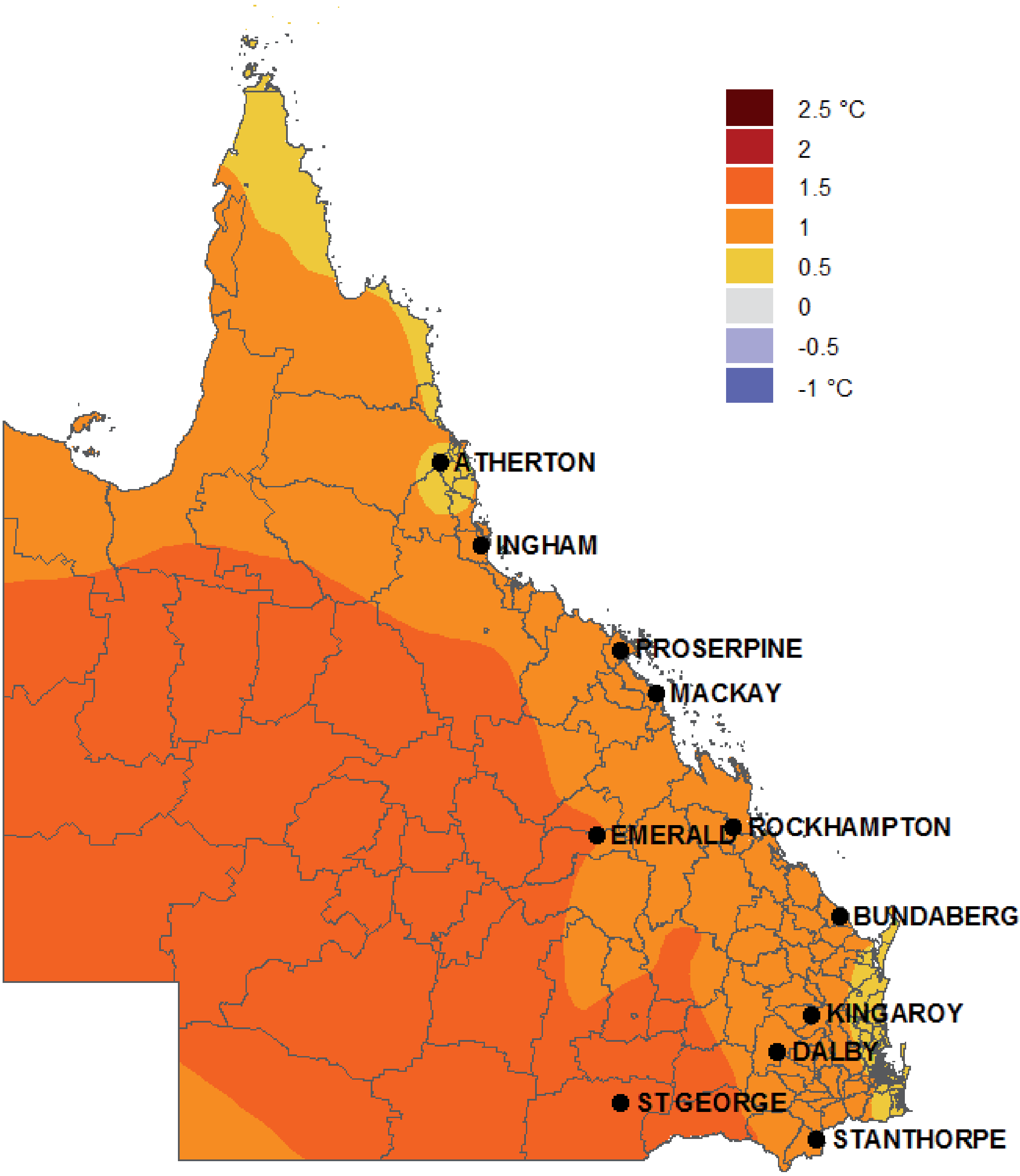
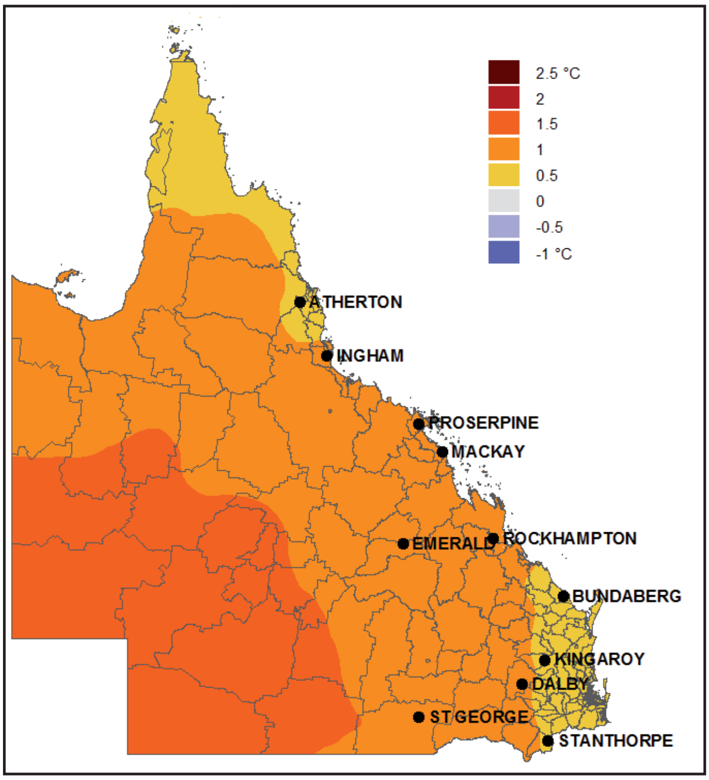
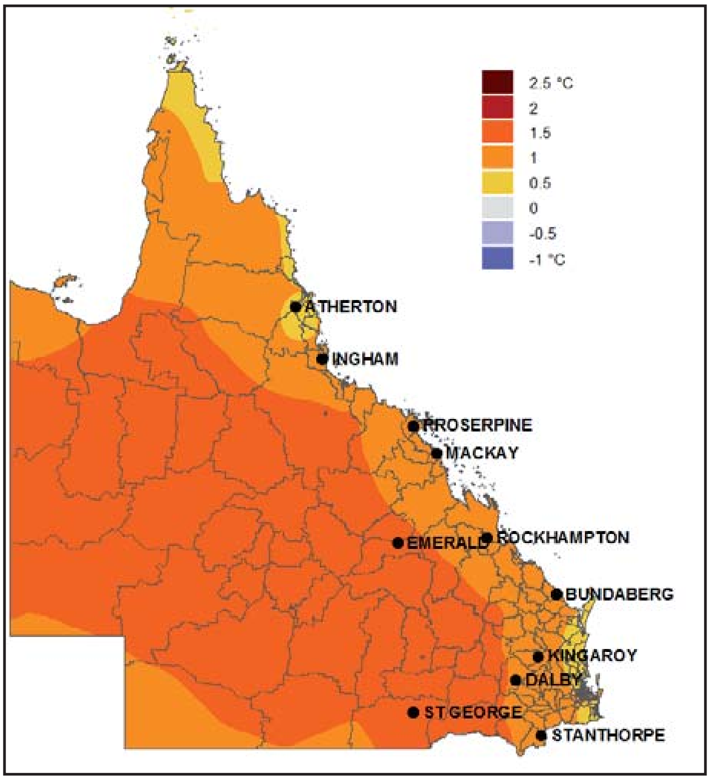


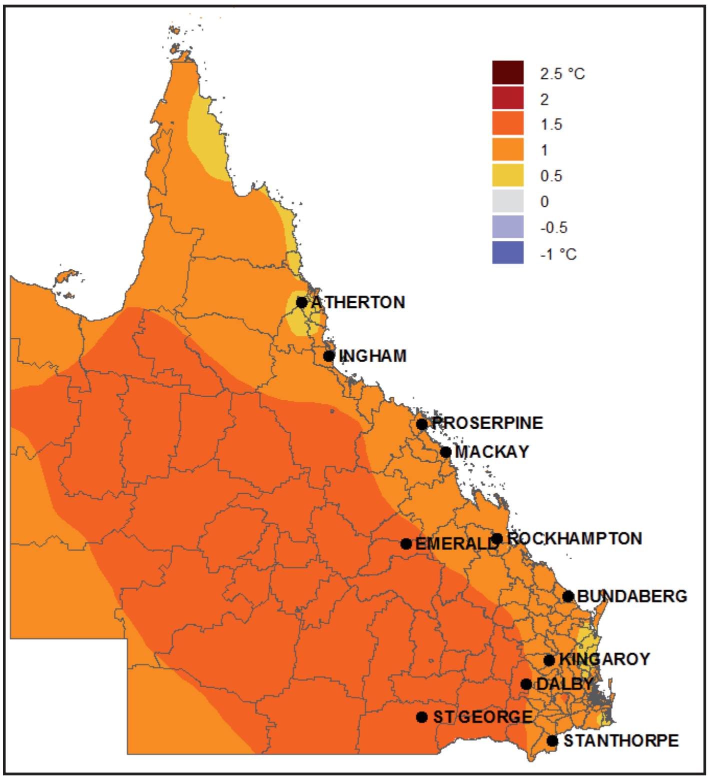
Figure 4: Projected annual temperature change in Queensland relative to the 1961-1990 baseline



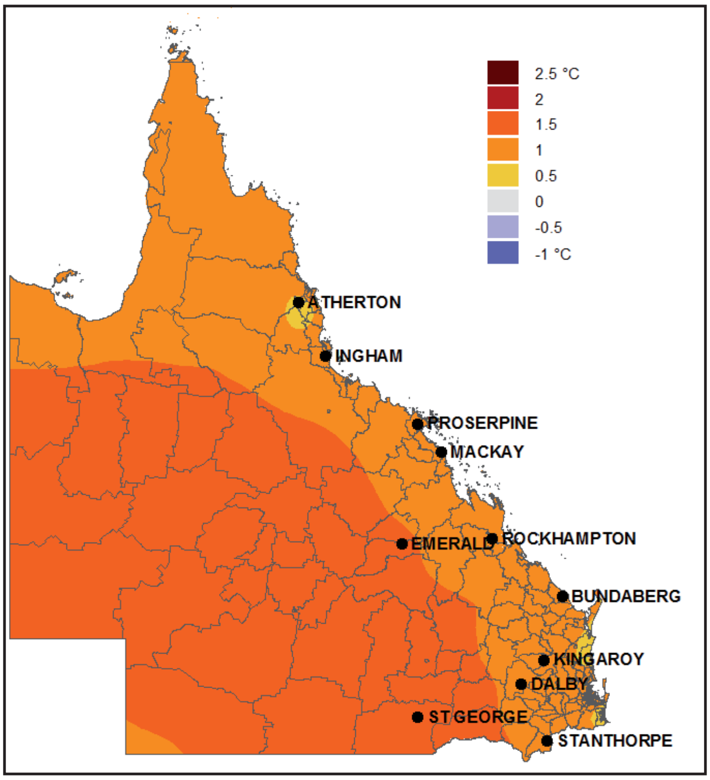
Projected temperature change by 2030 for the total period January, February, March



Projected temperature change by 2030 for the total period April, May, June.



Projected temperature change by 2030 for the total period: July, August, September.



Projected temperature change by 2030 for the total period October, November , December.

Figure 5: Projected seasonal temperature change in Queensland relative to the 1961-1990 baseline

Town	JFM	AMJ	JAS	OND	ANNUAL
Atherton	0.8°C	0.8°C	0.8°C	0.9°C	0.8°C
Bundaberg	0.9°C	1.3°C	1.4°C	1.2°C	1.2°C
Dalby	1.1°C	1.5°C	1.6°C	1.5°C	1.4°C
Emerald	1.3°C	1.7°C	1.6°C	1.6°C	1.6°C
Gatton	1.0°C	1.4°C	1.6°C	1.3°C	1.3°C
Ingham	1.2°C	1.3°C	1.3°C	1.2°C	1.2°C
Kingaroy	0.9°C	1.2°C	1.4°C	1.2°C	1.2°C
Lismore	0.9°C	1.1°C	1.1°C	1.1°C	1.0°C
Mackay	1.0°C	1.2°C	1.1°C	1.1°C	1.1°C
Proserpine	1.0°C	1.0°C	1.0°C	1.0°C	1.0°C
Rockhampton	1.2°C	1.4°C	1.4°C	1.3°C	1.3°C
St George	1.4°C	1.7°C	1.8°C	1.6°C	1.6°C
Stanthorpe	1.0°C	1.1°C	1.2°C	1.1°C	1.1°C

Table 2: Projected average seasonal temperature change in key Queensland regional centres relative to the 1961 to 1990 baseline

In general the results in Table 2 are similar to the findings of the Queensland Government (2008) which states that “by 2030, annual average temperatures in Queensland’s coastal areas are projected to increase by about 0.9 °C (range of 0.7–1.2 °C) relative to the climate of recent decades”. While broadly similar, the results in this report provide a more detailed and regionally specific estimation of temperature change, with additional information on regionally specific temperate patterns. Further research is needed to provide clearer future guidance on temperature averages and extremes.

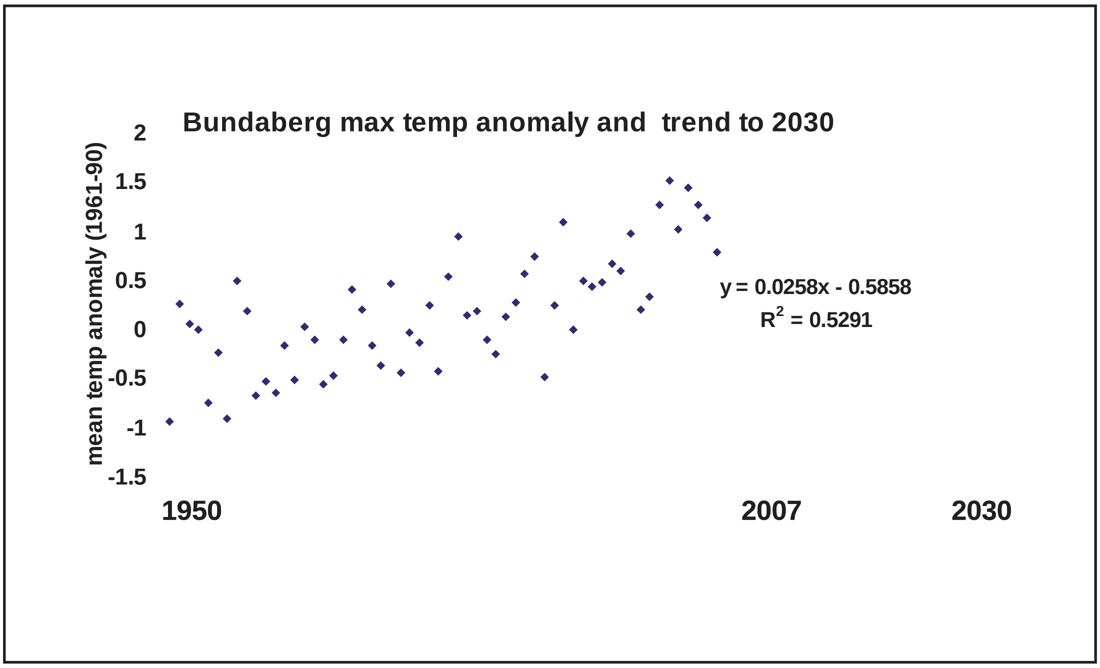


Figure 6: Maximum temperature data for Bundaberg 1950 to 2007.

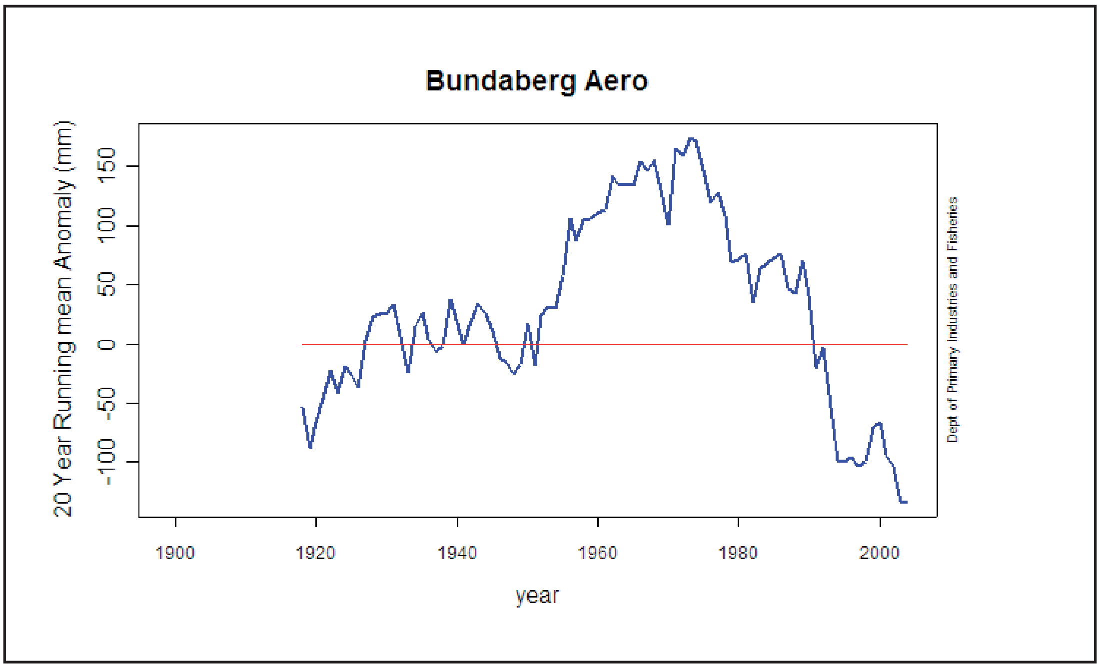


Figure 7: Past rainfall data for Bundaberg 1920 - 2007

Four key objectives of this project were the comparison of past climatic trentds with future projections. In general, the past trends over the last 50 years align with projected future changes to temperature and rainfall. Figure 6 and 7 show the past climatic records for Bundaberg. These images also demonstrate the importance for viewing short term climate variability within longer terms climate trends. Further data ona range of key production regions is available in the key report (Knapp & Perkins, 2008)

Projected Solar radiation changes in Queensland's future climate

Like temperature, solar radiation levels are also projected to increase over most of Queensland by 2030. The increase in solar radiation levels is due to decreasing cloud cover associated with reduced rainfall. On an annual basis (see Figure 8) solar radiation increases are generally greater towards the coast and less in inland and far northern regions. From a seasonal perspective, (see Figure 9) modelling shows that solar radiation varies considerably with no distinct pattern emerging beyond the southern movement of high solar intensity levels over the course of the year.

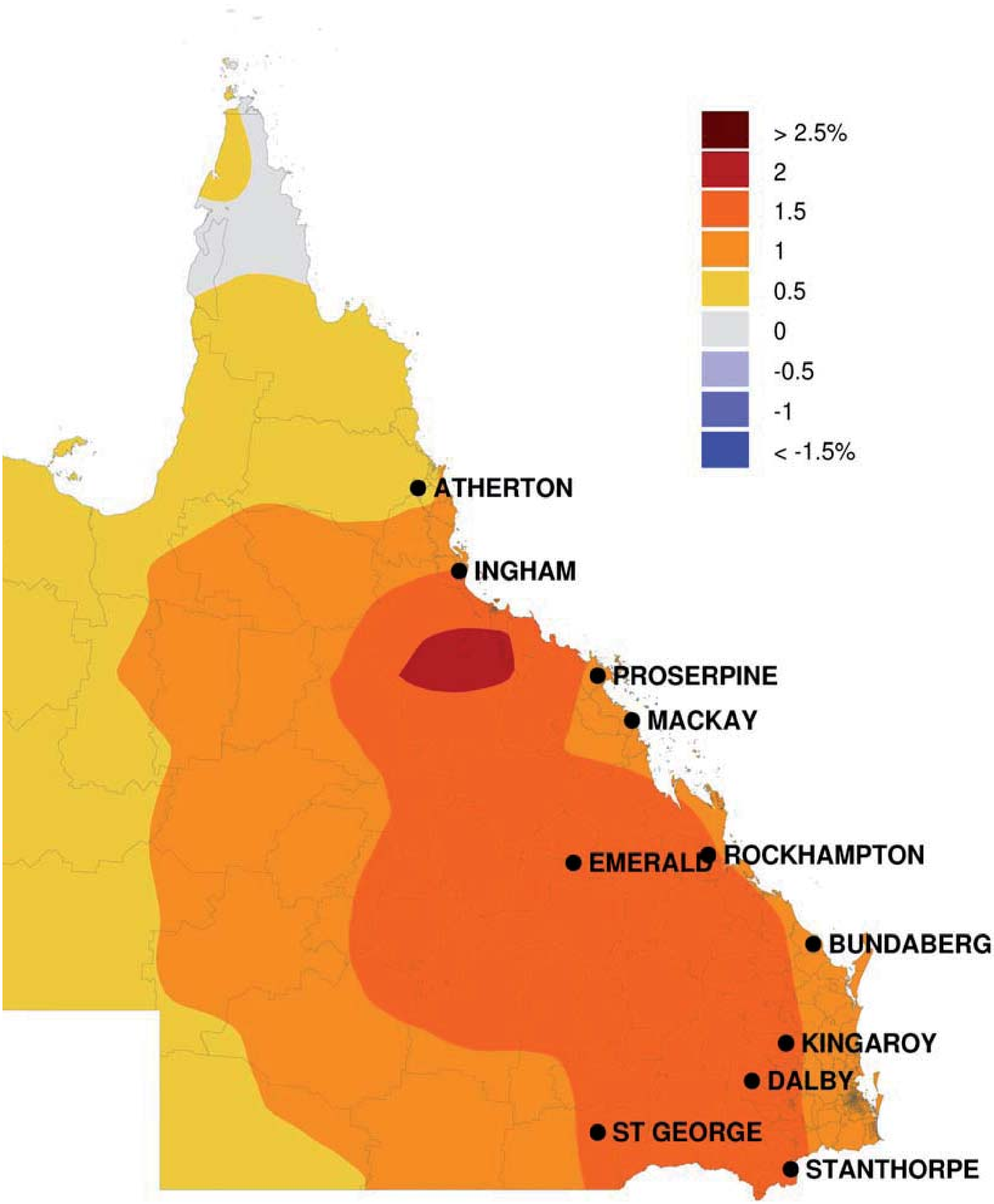
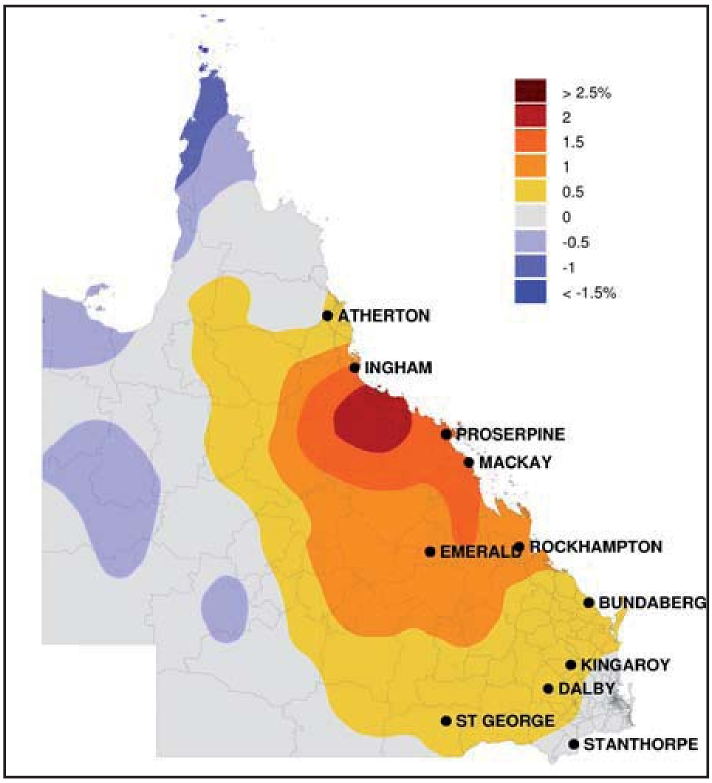
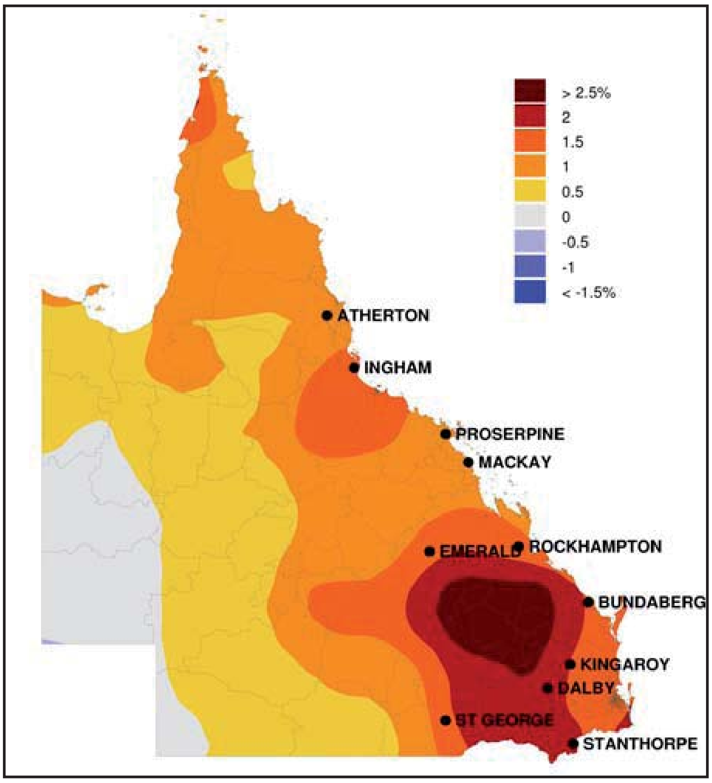


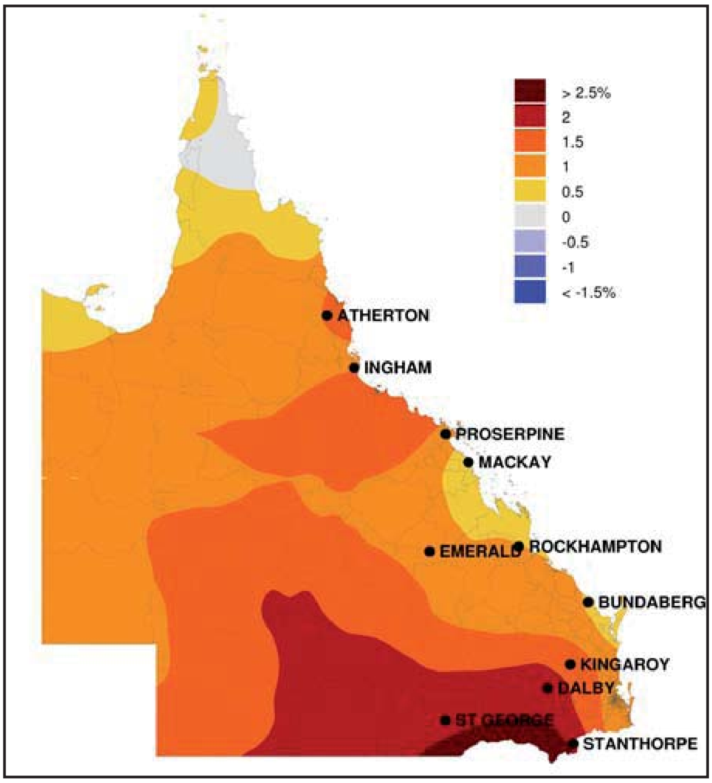
Figure 8: Annual radiation change in Queensland relative to the 1961 to 1990 baseline



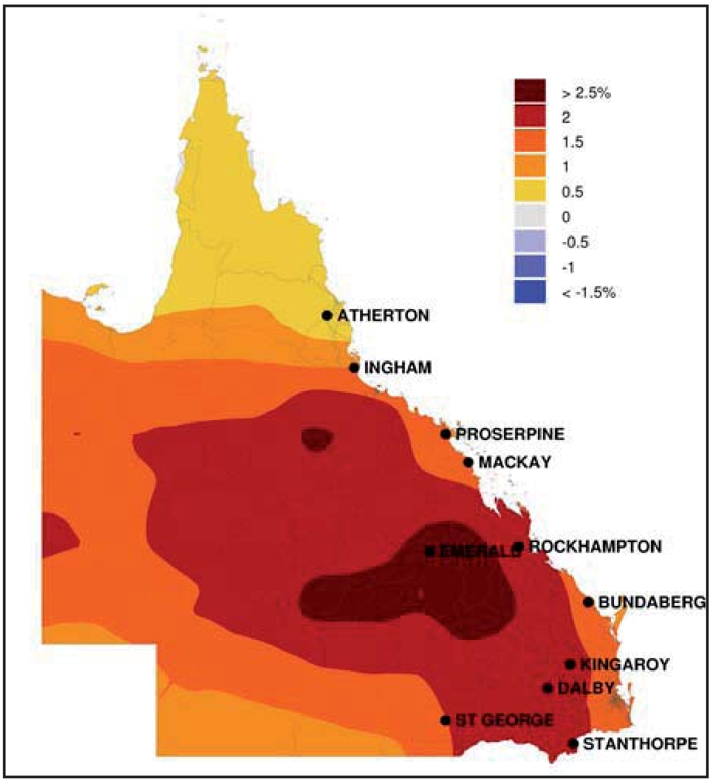
Projected solar radiation change by 2030 for January, February, March.



Projected solar radiation change by 2030 for April, May, June.



Projected solar radiation change by 2030 for July, August, September.



Projected solar radiation change by 2030 for October, November, December.

Figure 9: Projected seasonal radiation change in Queensland relative to the 1961 to 1990 baseline.

Town	JFM	AMJ	JAS	OND
Atherton	-0.1%	0.5%	0.9%	0.3%
Bundaberg	0.4%	1.6%	0.6%	1.4%
Dalby	0.0%	20.%	1.8%	1.6%
Emerald	0.8%	1.2%	0.7%	2.1%
Gatton	0.1%	1.3%	1.4%	1.6%
Ingham	0.9%	1.2%	0.9%	0.9%
Kingaroy	0.1%	1.4%	1.4%	1.7%
Lismore	-0.6%	1.5%	0.7%	1.2%
Mackay	1.1%	0.6%	0.3%	1.4%
Proserpine	1.0%	0.6%	0.5%	0.9%
Rockhampton	0.9%	1.3%	0.5%	1.9%
St George	0.3%	1.6%	2.1%	1.6%
Stanthorpe	-0.1%	1.5%	1.8%	1.7%

Table 3: Example of projected seasonal radiation change in key Queensland regional centres relative to the 1961 to 1990 baseline

Queensland's future climate and shifting seasons

One finding of this study that is of particular interest is the apparent shift in summer rainfall patterns. In general, seasons are defined by yearly changes in weather. Summer in Queensland is traditionally associated with a period of increased rain and high temperatures in the months of December, January and February. However, in the future, modelling results suggest that it may be more appropriate to define previously recognisable summer patterns as occurring in the January to March period. This outcome also suggests that weather patterns may shift by four to six weeks, meaning that the onset of the summer "wet" and winter frosts may be delayed.

Climate decision support tools

Several climate based decision making tools already exist to help producers better manage climate variability risk and improve the timing of farm activities with climatic events such as yield prophet. Integrating climate change projections with new and existing decision support tools will better equip farmers and industry to cope with long-term climate change. However, the capacity of climate decision support tools to assist producers is only as good as the climate information they are supported by. Thus, more detailed climate projections should be incorporated into decision support tools as they become available. Furthermore any such tools must start from a farm business perspective, be based on the language used by producers and be developed in partnership with industry (Bureau of Rural Sciences 2004).

Energy efficiency study of intensive agricultural industries in Queensland

On-farm energy efficiency is becoming increasingly important in the context of rising energy costs and concern over greenhouse gas emissions. Energy intensive machinery is used to move water, distribute nutrients, modify the farming environment, harvest, store and transport farm outputs. As a significant input cost, rising energy prices are a major challenge for intensive agriculture industries in Queensland. In six years, on-farm fuel costs have trebled (ABARE 2008). Electricity prices have risen almost 20 per cent in the last two years, and are projected to rise by up to 40 per cent by 2020 under the proposed emissions trading system. Hence, energy efficiency is increasingly important for farm businesses in adapting to the reality of rising energy costs and the need to mitigate emissions through energy efficiency. For these reasons, energy audits of different commodities were undertaken in order to develop a greater understanding of energy consumption and create a conceptual framework for future work on energy efficiency.

Energy audits are a crucial part of the energy and environmental management process. An energy audit refers to the systematic examination of an entity, such as a farm, to determine how efficiently energy is being used. Energy audits can also be used to identify energy and cost saving opportunities and highlight potential improvements in productivity and quality. Energy audits were conducted on a range of farming practices across South East Queensland including sugar cane, horticulture, nursery and some broadacre crops. This information was used to further increase industry groups understanding of energy usage within their industry's farming systems, and highlight associated opportunities to increase energy use efficiency.

Results showed that the energy intensity of different industries varies greatly. Despite variation between industries it was found that irrigation and pumping was a significant energy user for all industries. It was also found that harvesters used a significant proportion of energy on a farm. However, when minimum tillage and controlled traffic techniques are used, results showed that energy use could be reduced by approximately 20 per cent.

The energy intensity of the different commodities included in the energy audit can be seen in Figure 10. The total amount of greenhouse gas emitted as a result of the energy consumed was calculated using emission factors from the Australian Greenhouse Office (2006). Although helpful in comparing energy use, these graphs do not attempt to address the variation caused by different farming methods and different machinery. To include such detail, future research is needed to supplement the results from this study with other "technical" indicators of energy efficiency such as pump and tractor efficiency.

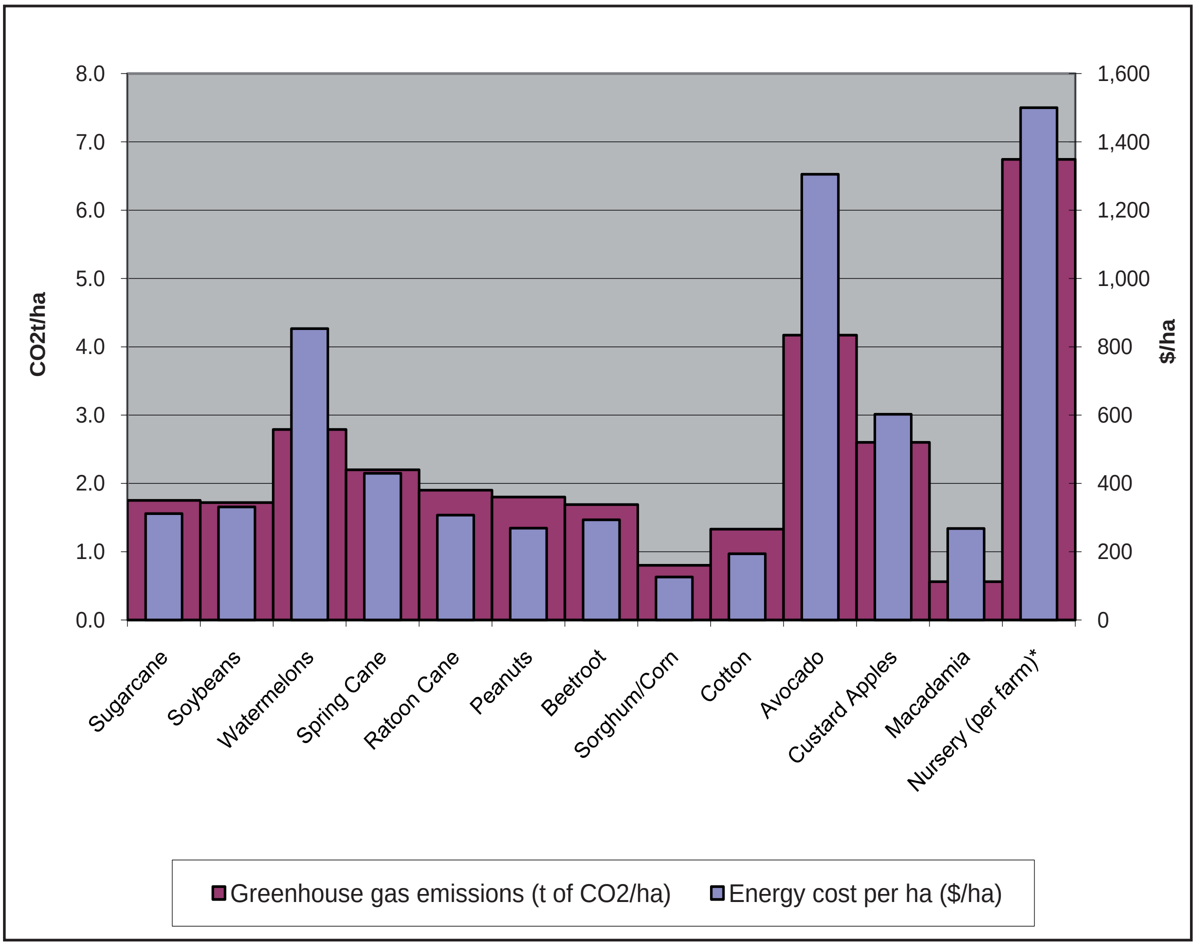


Figure 10: Energy use in production of different intensive industry commodities

Results from the energy audits showed that the Nursery Industry was by far the most energy intensive of the different industries surveyed. For the Nursery Industry, heating was the major energy user. Interestingly, significant differences were observed between horticultural commodities such as fruit (avocados) and vegetables (beetroot).

Finally, the intensive nature of the farming practices analysed in this study was evident in the differences in energy consumption between broad acre cropping (wheat and sorghum) and intensive agricultural industries. Information on electricity and on-farm fuel use has provided a valuable contribution in establishing the foundation for future energy efficiency studies on individual equipment and processes as a means of reducing energy consumption. In this regard, more work is required to fully benchmark energy consumption in the different industries mentioned in this study.

Tractor Performance Monitors

Tractor Performance Monitors (TPM) are increasingly being supplied as standard tractor electronic equipment, or a factory-fitted options for commercial tractors. They are able to provide key energy efficiency information such as engine speed, tractor forward speed, wheel-slip, and fuel consumption rate so that the operator is continually provided with useful information regarding the tractor’s performance. Using this equipment, the operators have the ability to configure and operate their equipment (for example gear up and throttle back) in order to provide the most effective and efficient operation. Examples include the John Deere 30 series tractor. Tractor Performance Monitors are a very useful data collection tool to assist with the implementation of detailed energy audits. It is believed that such recording systems will become more common in the future as energy prices continue to increase.

Farm management systems and the development of industry action plans

Farm Management Systems in Queensland's agricultural industries

A Farm Management System (FMS) approach to property management recognises the importance of equipping growers to make informed decisions through a structured risk based decision making system. Undertaking a FMS analysis of selected farm activities allows producers to identify and target specific areas of weakness and pinpoint specific action to better manage priority risks. In recent years, the FMS approach has gained increasing acceptance across the intensive agricultural industries and Regional NRM bodies as a useful planning tool to help guide investment and incentive delivery.

Adapting to climate change is fundamentally an issue of risk management. This makes the FMS approach well suited for managing climate change adaptation and assessing climate risk within the context of other on farm risks. Each commodity FMS responds to different needs, so the incorporation of climate change into commodity FMS programs will also vary. For example, the FMS dairy program, *Dairying Better N Better for Tomorrow*, is a structured industry led program providing a solid platform for delivery of technical information that leads to significant adoption of new practices and on-ground change. For the cotton industry, the FMS tool is the Cotton BMP program, originally developed as a tool for chemical management, but expanded to include land, water and soil issues.

The adaptation task facing rural industries in Queensland is immense. Research conducted by ABARE (2007) suggests that agriculture in Australia faces the greatest potential reduction in productivity of any major producer, and that Queensland industries such as beef and sugar face a greater challenge than industries in other states. While ABARE (2007) research shows agricultural industries still increasing productivity under climate change scenarios, the change is significantly reduced as climate change bites.

Clearly, the adaptation challenge is large (ABARE 2007). This challenge will become larger if agriculture is included in the proposed emissions trading scheme. In this way, the Garnaut Climate Review (2008) identified the cost of emissions permits in this sector as higher (as a percentage of revenue) for any other sector (*Garnaut Climate Change Inquiry Final Report 2008 p.208*). The cost of adaptation and mitigation responses can only be met through increased productivity from improved farming practices and management. In this context, the role of Farm Management Systems becomes critical.

In the past, intensive agricultural industries in Queensland have proven their capacity to cope with change and remain viable. However, the climatic changes projected to occur in future years may be of a greater scale and occur at a more rapid rate, than previously thought. Therefore it is prudent to examine a new level of risk management and adaptation options.

Results from climate modelling demonstrate that achieving more detailed and regionally specific climate projections to assist with farm management decisions is possible, however this information needs to be continually updated and verified. In general, the climate projections in this report confirm the findings and climate patterns of past climate projections such as Queensland Government (2008). Summer months are likely to be hotter and wetter but the climate throughout the rest of the year is predicted to be warmer and dryer. In addition, this report suggests that seasons in the future are likely to shift, as rainfall patterns in summer move later into the year. The detail provided in this report is another step towards providing producers with the detailed regional climatic projections with which to base risk management decisions.

Energy use in intensive industries is a major cost input and one of the main sources of greenhouse gas emissions. In this way, increasing the capacity of intensive agricultural industries to measure and increase energy efficiency has wide reaching benefits. This report has shown that energy use between intensive agricultural industries is highly variable and that significant opportunities exist to increase energy use efficiency. The quantification of energy use in various intensive agricultural industries outlined in this report is a significant step towards establishing a framework and methodology for a detailed energy emissions auditing process in the future.

Significant risks and opportunities exist for intensive agricultural industries in reducing greenhouse gas emissions and adapting to climate change. Although the issues vary considerably between different industries, regions and commodities, broad similarities also exist. Similarities include the negative impact of temperature increase on plant production and livestock heat stress, concern over the future availability of water entitlements for irrigation purposes, increase in pest and disease activity and the projected cost increases associated with the beginning of the Carbon Pollution Reduction Scheme. On the other hand, similarities in opportunities include the potential of increased production from plant based systems under elevated carbon dioxide levels, the increased capacity to use genetics and breeding to produce and market more adapted plant and animal varieties, and the emergence of new production regions as a result of changing rainfall temperature patterns.

Risks, opportunities, adaptation and mitigation must be examined in unison to prevent the development of adaptive strategies that further increase emissions and exacerbate the root cause of climate change. This report shows that industry based Farm Management Systems provide a highly effective risk-management framework from which to manage producers' climate change response. Combining information on adaptation and mitigation with the support of appropriate decision making tools such as Farm Management Systems will maximise the effectiveness of the future climate change response in intensive agricultural industries in Queensland.

Development of industry action plans

Each participating industry in the QFF climate change project developed a preliminary industry action plan to deal with the risks and opportunities associated with climate change in Queensland. This was undertaken in response to existing literature, results from the expert panel and industry workshops and the findings of new modelling projections for Queensland undertaken by USQ. During the QFF project, existing literature such as Howden et al (2003) was used to inform industry analysis of the issues confronting intensive agricultural industries as a result of climate change. Since this time, additional research such as CSIRO (2008) has become available that reinforces the position outlined in each industry action plan.

The following industry action plans identify the risks, opportunities and responses to climate change within the context of specific intensive agricultural industries in Queensland. These action plans make a direct connection between the capacity of industry FMS to assist producers manage and respond to climate change. Further detail on each industries strategy can be seen in the full QFF project report (Knapp & Perkins 2008).

Sugar industry - Canegrowers

Industry overview

Sugarcane production in Australia mainly occurs in discontinuous regions spanning 2100 km along the coast of eastern Australia within 50 km of the coastline. The four main identified regions are the Far North (Mossman in the north, south to Ingham), the Burdekin and Atherton Tablelands, the Central Region (Proserpine south to Maryborough) and the remaining areas in South East Queensland and Northern New South Wales. The four regions span a number of climatic zones, from the wet tropics, through the dry tropics to the humid sub-tropics. The three major climatic constraints on primary production are: water availability, radiation and temperature. Queensland's sugar cane production is valued at over $800 million a year and accounts for approximately 94 per cent of the country's raw sugar production.

Risks associated with climate change

The impacts of climate change on sugar cane production differs between regions. In the southern region, limited water supplies are likely to be exacerbated by the projected fall in rainfall levels. Land use competition from other crops (e.g. short duration annual crops) may increase.

In the northern region, increased water logging may limit paddock access, particularly during the growing season. Reduced spring rain would negatively impact crop establishment. In the Burdekin Region, the security of water supply from the Burdekin Dam may be threatened. Rising water table and salinity issues, exacerbated by rising sea levels, will require improvements in irrigation and better institutional arrangements in these irrigated areas. In the Central Region limited water supplies may be exacerbated by projected drying. Rising sea levels could result in poor drainage and tidal intrusion in the lower floodplains.

The Carbon Pollution Reduction Scheme and its impact on input prices poses additional challenges to maintain profitable and productive farming enterprises. Continued dialogue is required to ensure government policy takes into account the needs of primary producers.

Opportunities associated with climate change

Sugarcane's high biomass potential and ability to grow in marginal areas unsuitable for other crops could create new opportunities for production as a result of climate change. Higher temperatures could extend growing seasons and improve crop growth in frost-prone western districts. Less winter and spring rain may improve traffic ability and harvesting efficiency.

Cane-based renewal energy sources such as bagasse and ethanol also have considerable potential to benefit from increasing market demand for low-emission fuels. Sugarcane is increasingly being seen as an energy crop, with recent breakthroughs in crop breeding enabling the development of a high biomass, water use efficient varieties.

Industry response to climate change

A range of adaptation responses are needed across the entire sugar cane industry value chain in the coming years if it is to remain sustainable in a changing climate. Strategies must be tailored to individual regions in order to take account of differences in biophysical and logistical characteristics. Projected change in the amount, frequency and intensity of future rainfall represents a significant challenge for the industry. Demand for water is likely to increase due to greater rates of evapo-transpiration linked to atmospheric warming. Therefore a key adaptation response will be techniques aimed at improving efficiency of water use, such as precision irrigation.

Technological solutions including breeding new varieties with desirable traits such as greater drought resistance, water use efficiency, tolerance of increased temperatures and reduced lodging will also be viable adaptation solutions. Cropping system design and agronomic management strategies such as tree planting for shelter and soil protection, precision agriculture, laser levelling and diversification into alternative/additional crop species can also be used to reduce the impact of projected climate change on sugar cane production.

Institutional change is also likely to be important, such as changes in physical infrastructure (e.g. construction of seawalls and storm surge barriers) or industry reform such as the relocation of sugarcane production to more southerly areas to track poleward shifts of climate zones. While many adaptation options already exist, new research will be needed to fill the many of the knowledge gaps that remain in the adaptation strategies mentioned above.

Ongoing communication with the broader sugarcane industry about climate change adaptation will be vital in coming years. Climate change forecasting and diversification options are regularly featured in the industry magazine “Canegrower” as a positive feedback to growers about changing external forces on their business. In relation to mitigation, industry is aware of the economic impacts and benefits of emissions trading for cane production and is engaged in the consultation process on the establishment of the Carbon Pollution Reduction Scheme.

Finally, improved decision-making tools will allow cane growers to better respond to climate change. SmartCane, the Sugarcane Industry’s FMS is already used to help growers improve farm sustainability and profitability. It will be a critical tool to help growers manage the increasing risks associated with climate change, and includes auditing and financial planning tools to assist growers plan input optimisation, crop rotation and harvesting, pest and nutrient management strategies. SmartCane will continue to be fine tuned to respond to new risks.

Irrigation and climate change

Irrigation is a critical issue for intensive industries given its dependence on securing regular entitlements for irrigation purposes. The availability of water for irrigation will be significantly affected if climate change predictions for reduced rainfall are confirmed in coming years. Improved climate prediction is need for more detailed analysis of the impact of climate change on water availability across Queensland’s irrigation catchments, informing measures to plan and adjust for the impact of projected climate change on irrigation entitlements.

Under current water planning arrangements, the full impact of climate change on irrigation entitlements will be felt at the review of water resource plans that occurs every 10 years. Improved climate prediction and more detailed analysis of the impact of climate change on water availability across Queensland’s irrigation catchments would help identify planning measures to adjust for the impact of projected climate change when water resource plans are reviewed.

The recent CSIRO and Land and Water Australia (2008) analysis of the Murray-Darling catchments shows the depth of analysis required on a catchment-by-catchment basis to assess the impact of climate change on water availability. While findings from this report show that climate change models are being progressively improved, data deficiencies at the catchment and sub-catchment levels make the use of such modelling to predict the impacts of climate on water availability very uncertain.

Modelling results still do not have sufficient certainty to define and implement water entitlement security and environmental flow objectives through the water resource planning process. Therefore, ten year plan reviews using actual data on the impact of climate change during this period provide a better basis for water resource planning. Efforts must continually be made to develop a better understanding of the impacts of a drier and more variable climate, to inform the development of water resource plans and assist the management and improvement of irrigation schemes.

Fruit and vegetable industry – Growcom

Industry Overview

Queensland is Australia's premier state for fruit and vegetable production, growing one-third of the nation's produce, including the majority of Australia's bananas, pineapples, mandarins, avocados, beetroot and fresh tomatoes. Queensland's 2,800 farms operate in a variety of locations and climates and use a range of production methods to produce more than 120 types of fruit and vegetables. There are 16 defined horticultural regions, from Stanthorpe in the south to the Atherton Tablelands in the far north, with a total area under fruit and vegetable production of approximately 100,000 hectares. The nature of horticulture business is quite different to many other industries within the agriculture sector. Horticulture is the most labour intensive of all agricultural industries employing around 25,000 people in Queensland. Similarly, the capital investment required for horticultural production is usually relatively high, while profit margins are often tight. Furthermore, the majority of horticultural production systems are irrigated and therefore already use water highly efficiency.

Risks associated with climate change

Horticultural industries are more sensitive than many other agricultural industries to climate changes, particularly changes to temperature. Changing temperature, rainfall and water availability will mean that existing growing windows, production seasons and conditions are likely to change in the future. In general, the cumulative impact of increased temperature, reduced rainfall and increased carbon fertilisation will result in hotter, dryer production conditions with reduced chilling and maturing times and increased threat of pest and disease activity. These changes are likely to combine to make certain commodities in existing regions unviable in the future and further increase the cost of fruit and vegetables to the consumer.

More hot days and a decline in rainfall or irrigation are also likely to reduce yields. Heat stress and reduced winter chilling will impact production in some marginal growing regions. Water resources are also likely to be further stressed due to increasing demand yet decreasing precipitation. A decline in annual rainfall with higher evaporation rates would lead to a tendency for reduced run-off into rivers, with significant implications for security of irrigators' water entitlements. Finally, droughts and extreme weather events in Queensland are likely to become more frequent and more severe.

Beyond the physical impacts of climate change, the Australian Government's proposed Carbon Pollution Reduction Scheme poses additional challenges to the maintenance of profitable and productive horticulture enterprises in Queensland. At a minimum, the introduction of an Emissions Trading Scheme will increase the cost of basic inputs such as fertilisers and electricity. While it is often assumed that cost increases will be passed onto consumers, the highly competitive nature of the horticultural industry and the dominance of major supermarket chains such as Coles and Woolworths mean that growers are price takers with limited capacity to pass costs on.

Opportunities associated with climate change

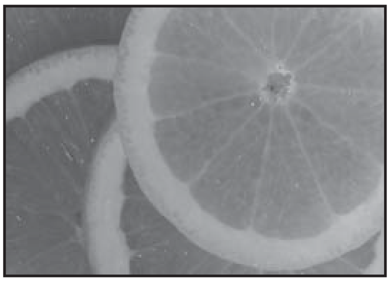
The impact of climate change and climate change policy on horticulture production will be both positive and negative and vary between regions and commodities. With changing growing seasons and regions may come new opportunities to access market windows or expand production into previously unfavourable or marginal areas. Increasing temperatures and atmospheric carbon dioxide concentrations will also mean that crops are likely to mature more rapidly and may be more water efficient. Similarly, projected increase in summer rainfall may offer enhanced opportunities for water collection and storage, if water harvesting regulations allow some flexibility.

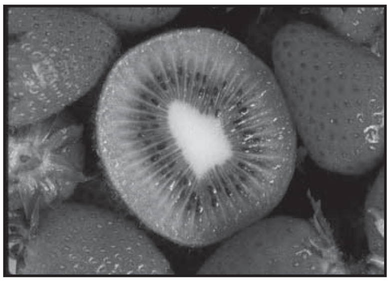
While the commencement of the Carbon Pollution Reduction Scheme poses considerable challenges, potential exists to further develop the capacity of horticultural production systems to capture carbon in crops or soils. Similarly, opportunities exist for the horticultural industry to promote low carbon impact products to growing niche markets of carbon conscious

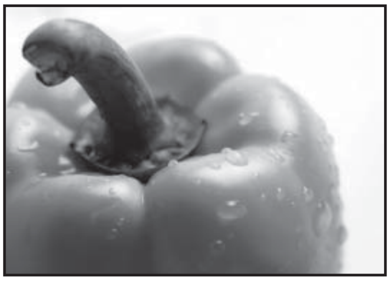
consumers or enhance "clean & green" or environmentally assured marketing initiatives in the broader market place.

Industry response to climate change

The past resilience of horticulture in Australia's highly variable climatic conditions is evidence that with appropriate industry and government support horticulture







can respond to this new challenge. Developing new fruit and vegetable varieties more adapted to increased temperature will help reduce the impact of increasing maximum and minimum temperatures. Similarly, reassessing planting and harvest times and the location of growing regions and will assist growers maximise new production opportunities resulting from positive influences such as elevated carbon dioxide levels and minimise the impact of negative change such as increased heat stress. Various management responses also exist to increase water use efficiency (such as deficient irrigation) and lessen the impact of temperature increase (such as evaporative cooling). However, little information currently exists on the impact of climate change on specific growing regions and therefore it is difficult for growers to know if they are likely to need to use such practices in the future. In response, Growcom in partnership with the Queensland Department of Primary Industries is commencing a project that investigates how increasing temperatures are likely to impact on the production of key horticultural commodities.

In adapting to climate change policy, growers also need to be equipped to minimise (and document) the carbon impact of their enterprises and farming operations and engage with the emerging carbon economy. In particular, more research is needed into the emissions from fertiliser use, methods to increase soil carbon levels and the overall cost impact of the Carbon Pollution Reduction Scheme on horticulture in Queensland. This information will help, increase growers awareness, reduce emissions and address the root cause of climate change. Growcom's existing FMS program provides an excellent framework with which to communicate adaption and mitigation options and assist growers respond to climate change.

For horticulture in Queensland, Growcom has developed a computer based FMS program based on different modules. The water module and the nutrient module have already been developed and are widely used to identify and manage risk. Growcom is currently developing a climate change and variability FMS module to assist growers better manage climate risk.

Nursery and Garden industry - Nursery and Garden Industry Queensland (NGIQ)

Industry Overview

The Queensland Nursery Industry is a significant horticultural sector with a combined supply chain valued at more than $0.5 billion annually, employing 6500 people spread over more than 2700 businesses including production nurseries, retail outlets and allied traders. The Queensland production sector of the Nursery Industry is located predominantly along the coastline, between the Tweed River in the south and Cairns in northern Queensland, with pockets of producers situated in various inland locations including Toowoomba, Emerald and the Atherton Tablelands. This wide distribution allows the industry to service local needs as well as target the interstate markets with a diverse product range. The production nursery sector services a wide range of end users including domestic gardens, commercial landscapers, developers, local government, fruit and vegetable growers and the forest industry.

Risks associated with climate change

Water security is the greatest climate change challenge faced by the production Nursery Industry. This is evidenced by the recent drought, which resulted in many business closures, financial difficulties and job losses. While irrigation best practice can to some extent minimises the impact of reduced water allocation, secure access to water supplies is fundamental.

Rising temperatures will also have significant impacts on the production Nursery Industry, altering the distribution of a range of current and potentially new pest and disease species. Changes to pest and disease lifecycles will occur as warmer temperatures prolong conditions suitable for more intense infestations and additional generations.

Increased temperatures are also likely to dramatically change cultivation methods in the industry. Crops that are currently grown in 'full sun' growing areas will need greater protection from increased temperature by the addition of costly shade structures. There is also likely to be an increase in the range of crops which require 'cooling'. Finally, temperature levels in containers may increase to levels where growth is either reduced or stops completely.

The proposed Carbon Pollution Reduction Scheme will also impact the industry through increases input costs (energy, fuel, fertilizer, pine bark etc). Growers who are historically 'price takers', will be unable to effectively pass these costs on. Growers are not currently well equipped to assist them in making 'low energy' or 'low emission' decisions.

Opportunities associated with climate change

The Queensland Nursery Industry is well positioned to be part of the climate change solution. The contribution of nursery crops to the urban landscape, fruit and vegetable, forestry and re-vegetation industries is significant. Ornamental trees and shrubs are not only aesthetically pleasing, they purify the air, minimise noise, provide a habitat for native fauna, lower energy consumption, consume carbon dioxide and produce oxygen. Trees can have a 'summer cooling' and 'winter warming' effect in urban environments and reduce the urban phenomenon know as the 'heat island effect'. Reduction in air temperature from 3 to 7°C is possible under a canopy of street trees. Potential also exists to extend the use of trees and gardens in built up areas through promoting ideas such as 'green roofs' and 'green walls'.

Climate change is also likely to create the opportunity for expansion into interstate and overseas export markets for Queensland growers who can adapt quickly to increasing temperatures. Finally, the large roof area and vast expanses of outdoor growing areas open up opportunities to consider the potential of renewable energy solutions such as solar power.

Industry response to climate change

Responding to climate change in the Nursery Industry will include changes in species, growing practices, more protective growing structures, movement of established growing regions and increased water storage capacity. Product in the production Nursery Industry is sold ‘live’, and growers face climate change constraints in both production and consumers’ capacity to establish plant stock. This means that securing access to sufficient water to establish and maintain plant stock is paramount for both growers and consumers. Higher temperatures and reduced water availability will drive the development of new plant varieties better adapted to the changing climate conditions. Growing practices such as container design, production area layout, growing media and water use efficiency will also need to be changed to reflect new climate realities. Farm management systems and practices must also be developed to respond to the increased risk of pest and disease outbreaks.

Nurseries are likely to be situated on much smaller landholdings than other agricultural enterprises, with a smaller carbon footprint. It is important that this is acknowledged when discussing climate change mitigation policies such as the Carbon Pollution Reduction Scheme. The many benefits of trees and vegetation as mitigating elements against climate change need to be further highlighted and acknowledged. A broad consumer education campaign is needed to promote effective ways to use nursery crops as part of climate change mitigation, along with research to quantify the benefits of the ‘urban forest’, plant varieties, innovative growing practices, biosecurity and renewable energy generation in production nurseries.

Promotion and further development of the Nursery Industry’s FMS is the most suitable way to prepare the industry for climate change. NGIQ is well positioned to play a role in the partnership between government and growers by raising grower awareness of climate change adaption and mitigation strategies via the FMS and supporting government incentives for on farm action. In the future, NGIQ plans to expand the its FMS to cover broader climate change issues, and assist decision making tools relating to climate forecasting data, carbon calculators, energy and water use efficiency and pests, diseases and weeds.

A risky business - Agribusiness, Banks and Insurance

The structure of supply chains in intensive agriculture is evolving with increasing linkages between family farm businesses and major retailers and processors. These linkages can vary from formal, integrated contractual links (e.g. chicken meat industry) to looser but continuing supply arrangements (e.g. aspects of horticulture). As these supply chain arrangements have emerged, cross linkages have developed between farmers, the professional services sector (science, accounting, planning, etc) and the financial sector. Supply chain arrangements can become a means for some risk sharing and transfer along the supply chain and a means to deal commercially with potential farm output fluctuations caused by climate variability.

The message coming from initiatives such as the Australian Business Leaders Roundtable on Climate Change (October 2007) was that climate change is real and significant but manageable, provided individuals and businesses have the right information and knowledge to identify and manage the risks and opportunities. For insurers, for example, while globally there is still a problem with ‘catastrophe’ risk management, Australia has a very good track record in coping with climate variability. Such variability makes it easier to accommodate risk associated with climate change into insurance markets. However, risk management becomes more difficult in conditions that are “unknown.” There is a risk that climate change could manifest itself with new weather conditions beyond what has already been experienced. This is clearly an area for more research, not just for risk managers, investors and underwriters, but for any business that is climate-dependent.

Dairy Industry - Queensland Dairyfarmers' Organisation

Industry Overview

The Northern Dairy Region incorporating Queensland and Northern NSW supports approximately 820 dairy farms producing around 680 million litres of milk annually. Numbers of producers have declined by half since 2000 due to the drought. In response, many dairy farms now incorporate supplementary feeding systems similar to beef feedlots rather than relying purely on irrigated pastures. Within the Northern Dairy Region there are seven major processing plants operated by four companies and more than 50 minor processing factories. The Northern Dairy Industry employs approximately 4600 people, incorporating 2700 on-farm and the remainder in processing and distribution. This industry is valued ex-factory at approximately one billion dollars per annum. The vast majority of milk produced by dairy farms in the northern region goes directly to the fresh milk market, with a modest proportion directed to manufactured products and export markets. Key production areas within the Northern Dairy Region include: South East Queensland; Wide Bay, Burnett, Central Queensland; Darling Downs and Atherton Tablelands.

Risks associated with climate change

The risks posed by projected climate change to the Dairy Industry are many and varied. Decreased annual rainfall and increased evaporation will increase the risk of reduced feed continuity, poor pasture quality and insufficient water availability. Similarly, the intensification of rainfall events will increase the risk of insufficient water storage as opportunity for regular "top ups" on pasture decline due to irregular rainfall.

Reduced milk production due to heat stress resulting from increased temperatures is also expected to be a major production risk in the future. Heat stress occurs when an animal is unable to sufficiently cool itself to keep within its thermal tolerance levels. Dairy cows suffering from heat stress reduce milk quality and production as a result of reduced feed intake, changed metabolic rates and blood hormone content and increased perspiration. In a similar way, increased temperatures will also increase livestock water consumption and irrigation needs, further increasing the risk of increased demand for declining water resources. Finally, increasing temperatures will shift the distribution of pests and parasites such as cattle ticks and buffalo fly in a southerly direction increasing the risk of infection, disease and reduced production.

Changes in temperature and rainfall are also likely to increase the need for supplementary feeding. Future price increases in feed stocks and basic farm inputs as a result of climate change are likely to substantially increase the cost of dairy products and reduce the viability of supplementary feeding measurers due to bio-fuel production and the commencement of the Carbon Pollution Reduction Scheme. In this way, dairy is particularly exposed to the commencement of an emissions trading scheme due to high levels of methane emissions from the digestive processes of cows.

Opportunities associated with climate change

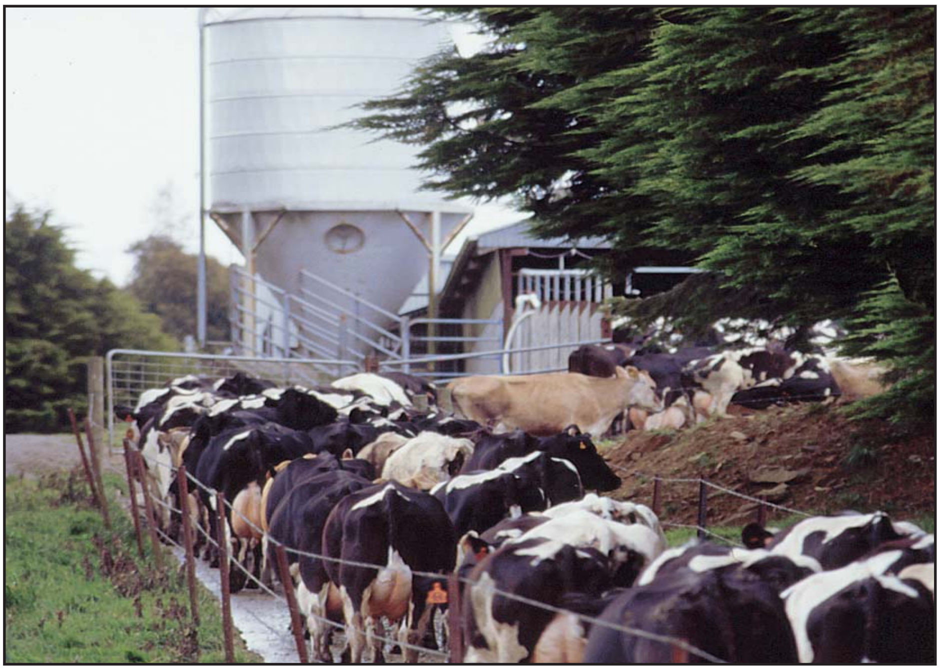
Some opportunities also exist for the Dairy Industry as a result of projected climate change. As with other industries, increasing atmospheric carbon dioxide levels are likely to increase plant biomass growth and increase water use efficiency. However the overall impact of increased temperature and decreased water availability is believed to outweigh this production increase. Furthermore, opportunities exist to sell tick vaccines to new producers in more

southerly regions such as NSW. Similarly, increasing temperatures will create a new market for improved cattle genetics more adapted to heat stress.

Opportunities also exist for reducing emissions though new technology and changes in practice. In this way, potential exists to develop and promote fodder systems that increase the uptake of carbon dioxide from the atmosphere. Systems could also be developed to harvest methane from manure and effluent. Finally effluent and manure could be harvested and sold as substitutes to manufactured fertilisers.

Industry response to climate change

The Dairy Industry can respond to the challenges of climate change in a number of ways. A variety of measures already exist to help producers respond to climate variability including improvements to water use efficiency, stock adjustment, use of feedlots and supplementary feeding, increasing shade through shelter trees, improved breeding for heat tolerance, naturally and artificially controlling the temperature in production sheds and using evaporative cooling to reduce heat stress.



In the future, additional measurers will need to be used to allow the Dairy Industry to adapt to climate change. These are likely to include greater use of summer housing of dairy cattle and the modification of grazing and reproduction times to avoid heat stress. Heat stress can also be prevented through further improvements in the design of the passive and active cooling capacity of production sheds. Further improvement in the feedstock composition can be used to reduce methane emissions. Finally, clustering dairy production with other compatible industries would also assist in maximising the benefit of complementary milk, food, power and waste based industries (Miller, Howden & Jones 2008).

Improving the farm management capacity of producers is critical to successfully responding to climate change in the Dairy Industry. Through an involved consultation process, Queensland Dairyfarmers', in collaboration with Dairy Australia are developing a Greenhouse Gas component to the existing *Dairying Better 'N' Bette*r FMS program.

Negotiations are also currently underway for the development of an extension module to address the issue of managing climate variability. This module will be specifically tailored to Queensland dairy farmers and advises on the need to address climate variability when making business decisions.

These business opportunities primarily relate to irrigation options, crop and pasture species selection, planting opportunities, herd management and forward contract purchasing. Improved soil-water conservation and maximising water use efficiency and productivity are key areas already included in this module. Finally, a series of farm extension advisory notes are being developed to better inform producers and industry service providers on a range of key climate change issues relative to the Dairy Industry.

Cotton industry - Cotton Australia

Industry Overview

Most Australian cotton farms are owned and operated by family farmers, are typically between 500 to 2000 hectares, are highly mechanised, capital intensive, technologically sophisticated and require high levels of management expertise. About 80 per cent of cotton farms are irrigated and generally grow other crops such as wheat and sorghum and/or graze sheep and cattle. Cotton can be grown either as dryland (which means it relies on rainfall) or as irrigated cotton (requiring supplemented water supply by irrigation). Both dry land and irrigated cotton require regular and predictable rainfall particularly during summer periods of extreme heat with low humidity.

The higher the average temperature and amount of direct sunlight during the growing season, the faster the crop will grow and develop. The longer and hotter the growing season, the higher the potential yield. Irrigated cotton grows with improved quality in low rainfall environments because of the ability to control the level of moisture in the soil.

Queensland normally produces about 30 per cent of the nation’s cotton crop, but recent drought has cut production dramatically. The Queensland cotton industry is concentrated in areas where normally reliable summer irrigation supplies are available. The dryland area (rain fed) is normally an opportunity crop when conditions suit.

The industry is characterised by significant reliance on specialist agronomic and crop monitoring services while the crop is growing, and specialist harvesting and transport contractors for picking and delivering to regionally based cotton gins. This feature means that a number of Queensland’s regional centres have a significant reliance on the cotton industry. The main Queensland cotton growing regions are Darling Downs, St George – Dirranbandi, Border Rivers (Goondiwindi), Central Queensland (Emerald) and Dawson Valley.

Risks associated with climate change

Climate change is likely to have a number of key impacts on cotton production. Cotton is suited to warm climates; it is affected by temperatures below 12 degrees ^{o}C (cold shock) and above 36 degrees ^{o}C. Decreases in the number of cold days due to climate change may prove beneficial to cotton production; however, the associated increase in days above 35 degrees ^{o}C may be detrimental. Fibre quality of both irrigated and dryland cotton is significantly affected by both temperature and water availability. These impacts may vary with the time of season and interactions with other variables. Because international markets are increasingly focused on optimal fibre quality, managing this important characteristic is likely to become a greater challenge to Australian growers as the climate changes.

Opportunities associated with Climate Change

A number of opportunities exist for Cotton which include:

Cotton and temperature:

Climate change has the potential to impact on many facets of cotton growth and development. The industry does not as yet understand:

- the inter-relationships of impacts of changes in rainfall, in carbon dioxide concentration, reduced water availability, increased atmospheric evaporative demand (lower humidity), and increases in temperature;
- the relative degree of impact caused by the growing of cotton in different regions

On the face of it, an increase in CO_2 could increase crop yields. However these increases could be completely offset by a lack of available water for irrigation. Furthermore, temperature extremes that could deliver a longer growing season are counter balanced by extremes that render the crop difficult to germinate or reluctant to develop to maturity. These agronomic impacts would also have dramatic flow-on consequences in fibre quality decline.

The industry has some very well established cotton crop modelling programs. While they work adequately to predict how crops behave in current growing conditions and regions, a lot more work is required to run these models for outcomes under future climate scenarios. This knowledge, coupled with climatic predictions at a much more relevant scale, (e.g. a catchment scale) would make long term planning far more reliable.

Cotton and greenhouse gases:

Greenhouse gases emitted through cotton growing include:

- carbon dioxide (CO_2) from soils through the decomposition of soil organic matter especially after cultivation;
- carbon dioxide (CO_2) from fuel and energy use during cultivation, planting, harvesting, pumping, transport and ginning;
- nitrous oxide (N20) from fertiliser and organic Nitrogen sources;
- methane (CH_4) from water logging.

Existing industry research indicates that nitrous oxide released into the atmosphere from the process of denitrification is the most significant greenhouse gas contributor in cotton production. It is of greater significance in irrigated soils particularly when high rates of nitrogen based fertilisers are used. The cotton industry has been measuring nitrous oxide emissions through research trials and this work has resulted in a reduction in the IPCC default benchmark for cotton production.

Cotton Greenhouse gas calculators

The cotton industry has already funded work to develop a Cotton Greenhouse Gas Calculator. This tool calculates an estimate of a farming enterprises greenhouse footprint by comparing the relative contributions from fuel, soils and nitrogen for that operation. The industry has also funded a separate energy calculator. This tool has been developed through series of on -farm audits to measure energy use in the cotton productions system.

Industry response to Climate Change

Queensland cotton growers have already been successfully managing their business while dealing with a highly variable climate. The industry has been funding activities and research designed to arm cotton growers with knowledge and tools to deal with future climate scenarios for many years. The industry has moved a step forward in filling a number of critical knowledge and resource gaps and is in the process of establishing a nationwide approach to the challenges of climate change as it works to coordinate its research, extension and communication efforts over the coming years. Cotton Australia believes a nationally coordinated, regionally delivered program, for the cotton industry will be the only truly effective way of supporting farmers dealing with this very complex issue.

Prawn industry - Australian Prawn Farmers Association

Industry Overview

Aquaculture prawn farming began in the 1980's with most farms being located on flat land adjacent to sea water sources, such as tidal rivers or creeks. Prawn farms require temperatures above 25 degrees during production season. For this reason, 80 per cent of farms are located in Queensland. Prawn farming is Queensland's largest aquaculture sector providing the equivalent of 300 full-time jobs, mostly in rural communities and producing in excess of 3,000 tonnes of product for an annual value that exceeded $42.5 million per annum in 2006/07.

Total land currently used for production is in excess of 900 hectares and clusters of the farms can be found on the Logan River, Mackay, Townsville, Cairns and two farms located in Yamba, NSW. It requires approximately six months for prawns to grow to harvesting size and most of the prawns are sold domestically in Australia. Processing is carried out as soon as harvested with most farms having their own processing facilities that include grading, cooking and freezing.

Risks associated with climate change

The inundation and pond damage is a result of rising sea levels and increasing flood and cyclone intensity is a key risk for aquaculture producers. Declining and changing rainfall patterns also pose additional risks associated with changing the distribution patterns of marine organisms and therefore reducing suitability of existing marine habitats. Finally, the introduction of the Carbon Pollution Reduction Scheme will increase the cost of power and therefore the cost of operating pumping machinery, further increasing overall production costs.

Opportunities associated with climate change

Increased water and air temperature is likely to favour higher production in the prawn industry. However, this opportunity can also be seen as a risk due to the potential for increased competition for Queensland prawn farmers from new production regions further south. In addition, emerging opportunities exist in the capturing of carbon in algae. However further work needs to be carried out to measure the amount and permanence of algae grown in aquaculture production systems.

Industry response to climate change

The Australian Prawn Farmers Association (APFA) recognises the importance of early adaptation to Climate Change. Current priorities for APFA include the identification of the carbon footprint of prawn farms. This investigation includes auditing the use of energy and potential energy efficiency improvements and investigating the potential of algae to capture and store carbon.

Chicken meat industry – Queensland Chicken Meat Council

Industry Overview

Chicken makes up around 34 per cent of consumers' meat diets. Most commercial meat chicken farms are intensive, highly mechanised operations that occupy relatively small areas compared with other forms of farming. The Queensland Chicken Meat Industry is predominately centred in the South East corner of the state and has experienced strong growth over past decades, contributing more than 20 per cent to the Australian chicken meat output valued at over $600 million. The South East Queensland chicken industry operates in close proximity to major urban and tourist centres and is therefore an industry used to close scrutiny of its production processes. To ensure both high quality production and environmental outcomes the chicken meat industry is one of the early adapters when it comes to delivering and implementing FMS to improve farm operations. For this reason the Queensland Chicken Meat Industry is an active player in the Australian Chicken Meat Federation (ACMF) to actively pursue the identification of risks, opportunities and responses to climate change for chicken meat production in Queensland.

Risks associated with climate change

The predicted warmer, drier conditions would increase heat stress management issues for chicken meat producers in Queensland. Animal heat stress is linked to air temperature, relative humidity, wind and solar radiation. When conditions are outside the "critical temperature range" for a species the animal's response quickly affects production efficiency.

Climate change will impact on the cost and availability of feed ingredients as bio-fuels, carbon farming and direct foods continue to compete for limited productive land. Chicken meat producers, as intensive energy users, are also likely to face significant increased in energy costs associated with the introduction of the Carbon Pollution Reduction Scheme. Intensive livestock farmers also need to be cautious of partial solutions to the challenges posed by the complex issue of climate change, especially in regards to water and energy use. Mal-adaptive and reactionist strategies from government and or industry would be detrimental for both farm production and consumers.

Opportunity associated with climate change

The Queensland Chicken Meat Industry is well positioned to be promoted to consumers as a sustainable, low emissions source of affordable protein. This is because chicken meat production has a high conversion rate of feed stock to animal weight gain and "low food miles" compared to other forms of meat production due to the proximity of production regions to urban areas. Furthermore opportunities exist for the increased reuse of chicken manure in fertilisers as the price of synthetic fertilisers increases due to the commencement of the Carbon Pollution Reduction Scheme in 2010.

Industry response to climate change

The Chicken Meat Industry recognises that while current production is highly efficient, industry needs to more fully understand its comparatively small "carbon footprint" to ensure that consumers' understanding of the benefit of chicken meat is based on hard science. In this way, ACMF is undertaking a national Carbon Footprint Project to document and benchmark emissions and energy use in chicken meat production. This information is necessary to understand how food production and processing sectors contribute to national emissions and document how shifting public opinion might ultimately impact on consumer spending patterns.

On a farm scale, a FMS framework provides the most systematic approach to evaluate the impacts of climate change on business decisions. An FMS approach allows farm level adaptations to be tested against existing policy, technology and research. In this way, existing FMS structures are being adapted to include the findings of new research.

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