Maximising returns from water in the Australian vegetable industry: Queensland

Craig Henderson,
Department of Primary Industries and Fisheries, Queensland

June 2006

Queensland Government
Department of Primary Industries and Fisheries

HAL
Know-how for Horticulture™

Vegetable R&D

AUSVEG

This project is facilitated by Horticulture Australia Limited (HAL) in partnership with AUSVEG and is funded by the National Vegetable levy. The Australian Government provides matched funding for all HAL's research and development activities.

Maximising returns from water in the Australian vegetable industry: Queensland

Author: Craig Henderson, Principal Horticulturist, Queensland Department of Primary Industries and Fisheries

Acknowledgments

Thanks to Max Durham, vegetable grower, for comments on irrigation systems, and Mark Hickey, NSW DPI, for his editorial assistance.

Published by NSW Department of Primary Industries

ISBN 0 7347 1719 9

First published June 2006

For updates to this publication, check http://www.dpi.nsw.gov.au/

jn6466

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

This report is one in a series on vegetable industry water use at state and national levels, and has been funded by Horticulture Australia Ltd (HAL) and AUSVEG. This series outlines how water is used in the major vegetable production regions in Australia, and details the current irrigation practices, water use efficiencies and economics of the vegetable-growing industries in each state.

The vegetable sector is the largest segment of the horticultural industry in Australia. The most recent ABS survey (2000/01) revealed the vegetable industry had a gross value of around $ 2.1 billion, derived from some 2.9 million tonnes of produce. Export value of Australian fresh and processed vegetable products in 2004/05 was in excess of $192 million. The major crop types were potatoes (1.2 million tonnes from 36 800 ha), tomatoes (414 000 tonnes from 8300 ha), carrots (283 000 tonnes from 7000 ha) and onions (247 000 tonnes from 5300 ha).

The 2000/01 ABS survey reported 5300 vegetable establishments (with estimated value of agricultural operations worth $5000 or more) Australia-wide, directly employing 15 621 people. These farms were typically run by single unit farming families who specialise in vegetable production. Average farm size is about 25 hectares, from which produce worth $230 000 per annum at first point of sale is generated.

The 2005 ABS report *Water use on Australian farms* stated that, in 2002/03, the vegetable industry accounted for 439 229 ML, or just 4.2% of the total water used for irrigation. The report also estimated that average water use per hectare was 3.9 ML/ha, compared with the estimated overall application rate for water across all crops of 4.4 ML/ha. The value return from vegetable production per megalitre increased from $1762/ML in 1996/97 to $3207/ML in 2000/01 (ABS 2005).

The rate of irrigation technology improvements in the vegetable industry since the mid 1990s has been significant, and has come at a time of increased publicly funded incentive programs (such as WaterWise on the Farm in NSW and Water for Profit in Queensland) for improving irrigation efficiency on farm. This series of reports details the investment made in technology to ensure maximum output and product quality from every megalitre used in vegetable production and processing.

The productivity increases achieved by the vegetable industry can be largely attributed to the increased use of water-efficient delivery systems such as drip irrigation, increased use of recycling on-farm, wide scale adoption of irrigation scheduling and soil moisture monitoring and increased use of whole farm planning and soil mapping. Although more difficult to measure, some part of that increase in product value and quality is most likely to be the direct result of improved irrigation practices.

VEGETABLE INDUSTRY WATER USE IN QUEENSLAND

This report, one in the series of reports on vegetable industry water use at state and national levels, provides a summary and analysis of water use in the vegetable industry in Queensland as of March 2006.

The Queensland vegetable industry was worth $641 million at the farm gate in 2001 (CDI Pinnacle Management and Street Ryan & Associates 2004). Estimates of the area of irrigated vegetables vary from 34 000–38 000 hectares per annum, with an irrigation investment of 110 000 ML/year (ABS 2004; ABS 2005a; CDI Pinnacle Management and Street Ryan & Associates 2004). This quantity of irrigation represents less than 6% of the annual crop irrigation in Queensland, yet produces 19% of crop value (CDI Pinnacle Management and Street Ryan & Associates 2004).

The cumulative value of Queensland vegetable industries is the largest by value (around 30% in 2001, ABS 2004) in Australia. It is characterised by diversity, ranging from winter production of tropical vegetables in the Far North to summer production of winter vegetables on the Granite Belt, at the Queensland–NSW border. In 2001, there were around 1460 enterprises throughout the state growing vegetables, with an average holding size of 26 ha. Enterprise form and size is highly variable. For example, vegetable farms may be only 9–12 ha in the south coast areas, compared with 60 ha in Bowen–Mackay or the Western Darling Downs (CDI Pinnacle Management and Street Ryan & Associates 2004).

According to ABS 2004, Queensland's 'Big 6' vegetable industries (making up 63% of total Queensland vegetable value) are tomatoes ($135 million), capsicums and chillies ($60 million), all melons ($57 million), potatoes ($47 million), lettuces ($43 million) and french beans ($32 million).

Including downstream industries and operations, CDI Pinnacle Management and Street Ryan & Associates 2004 estimate the worth to Queensland of vegetable industries at $1.3 billion per annum, providing 13 500 jobs in regional Queensland. This equates to $1.2 million of total vegetable regional output, and 12 regional jobs, for every 100 ML of irrigation water applied to vegetables.

In all regions except the Far North, Wide Bay and South Coast, pan evaporation exceeds rainfall by more than 200 mm in every 3-month interval during the main vegetable growing periods. In the Far North, Wide Bay and South Coast, the summers and autumns are more accommodating, with a difference of 50–150 mm for each of those 3-month periods. (The deficit is also only around 100 mm during the South Coast winter.)

These dry production climates and substantial evaporation deficits reduce the risks to crop yields and quality from waterlogging or water-enhanced plant diseases. It also means that, without irrigation, profitable production is virtually impossible. Most Queensland vegetables are currently benchmarked at using between 2 and 4 ML/ha per crop. These values are obviously dependent on growing region, crop type, and irrigation system employed. Compared with sugar cane, cotton, and the groups of irrigated pastures and cereals, vegetable irrigation consumes about 5% of the state's irrigated production water use. This does not include irrigation for home, parks or gardens.

Initial analysis suggests that many of Queensland's vegetable crops return a gross margin value of between $500 and $2000 per megalitre of irrigation water used. Simple sensitivity analysis demonstrates that dropping vegetable farm gate prices by 20% (a common market scenario) means 8 of the 17 vegetables analysed become unprofitable, thus returning a negative gross margin water use efficiency (WUE). This shows the importance of having a profitable and resilient market for product in terms of getting a return on increased investment in irrigation improvements, or indeed in switching to supposedly more 'water-efficient' crops.

In response to water shortages, extension and incentive programs and production imperatives, many Queensland vegetable producers have adopted irrigation scheduling devices, whether simple (e.g. tensiometers, gypsum blocks) or complex (e.g. capacitance probes, logging matrix sensors). Rates of adoption are associated with the presence of advocates and back-up service, reliability of devices, incentive programs such as the Rural Water Use Efficiency (RWUE) initiative, and user awareness and skilling programs.

In the last decade there has been significant investment in changing and improving irrigation system infrastructure in the Queensland vegetable industry. A major component of the RWUE program has been system evaluation and recommendations for improvement or change. An example of a typical improvement is changing pump configurations and performance to improve energy efficiency by more closely matching system requirements. This has been particularly common where producers have moved from high pressure systems, such as hand shift sprinklers or travelling guns, to low pressure booms or drip tape.

Another common response to an adverse evaluation of the low distribution uniformities of existing designs and equipment is reconfiguration of sprinkler systems. The reconfigurations included reduced lateral spacing in solid-set sprinkler designs to improve overlap, changing sprinklers to more wind-resistant heads, or changing sprinkler or boom nozzles to match irrigation output with soil infiltration rates.

As the droughts have hit regions hard, there has been a huge increase in utilisation of drip systems for vegetable production. In many solanaceous and cucurbit crops, this was already common since the late 1980s, but the use of drip tape has expanded recently to crops such as potato, sweetpotato, lettuce, brassicas, beans and sweet corn. The move to drip tape is often accompanied by an increased adoption of automation of irrigation controllers.

In recent years, Queensland vegetable producers have accessed information and training through programs such as the Water for Profit component of the Rural Water Use Efficiency initiative, CRC Irrigation Futures, DPI&F information and research and development activities, Irrigation Association of Australia, consultancy and agribusiness services. For example, in the four years of the Water for Profit program up to June 2003, 1500 growers participated in best management practice activities, there were 6000 workshop attendances, and 1440 growers were assisted through the Financial Incentive Scheme. The Water for Profit program calculated a return of $23 in efficiency gains for every $1 invested in the program by the Queensland Government (Clark 2003).

RECOMMENDATIONS

Based on the analyses in this report, recommended follow-up activities are:

- investigation of methods to increase collection frequency of consistent, reliable, verifiable volumes and prices of production inputs and outputs for vegetable industries across Australia
- regular analysis of industry trends and issues, similar to the HAL and Growcom funded study Economic contribution of horticulture industries to the Queensland & Australian economies (CDI Pinnacle Management and Street Ryan & Associates 2004)
- development of a program to regularly update regional vegetable crop gross margins, which are the fundamental building blocks for enterprise or industry analysis
- investigation of the technical reasons for differences in water use efficiency indices between regions for like crops
- development of economic models that incorporate fluctuating water, yield and price scenarios as tools to enhance the evaluation and comparison of vegetable enterprises and industries and the impacts of changing technologies and external environments
- provision of guidelines that vegetable producers can readily adopt to assist them to effectively and sustainably use alternative water sources, such as recycled water or non-potable aquifers.



SECTION 1 – OVERVIEW OF THE QUEENSLAND VEGETABLE INDUSTRIES

The Queensland vegetable industry was worth $641 million at the farm gate in 2001 (CDI Pinnacle Management and Street Ryan & Associates 2004). Estimates of the area of irrigated vegetables vary from 34 000 to 38 000 hectares per annum, with an irrigation investment of 110 000 ML/year (ABS 2004; ABS 2005a; CDI Pinnacle Management and Street Ryan & Associates 2004). This quantity of irrigation represents less than 6% of the annual crop irrigation in Queensland, yet produces 19% of crop value (CDI Pinnacle Management and Street Ryan & Associates 2004).

The cumulative value of the vegetable industries in Queensland is the largest by value (around 30% in 2001, (ABS 2004)) in Australia. It is characterised by diversity, ranging from winter production of tropical vegetables in the Far North to summer production of winter vegetables on the Granite Belt, at the Queensland–NSW border. In 2001, there were around 1460 enterprises throughout the state growing vegetables, with an average holding size of 26 ha. Enterprise form and size is highly variable: for example, vegetable farms may be only 9-12 ha in the South Coast areas, compared with 60 ha in Bowen–Mackay or the western Darling Downs (CDI Pinnacle Management and Street Ryan & Associates 2004).

Queensland's 'Big 6' vegetable industries, making up 63% of total value, are:

- tomatoes ($135 million; mostly Bowen–Mackay and Wide Bay; 30% of Australia's production)
- capsicums and chillies ($60 million; mostly Burdekin, Bowen–Mackay, Wide Bay; 43% of Australia's production)
- watermelons, rockmelons and honeydew melons ($57 million; mostly Burdekin, Bowen/Mackay, Wide Bay, Darling Downs; 45% of Australia's production)
- potatoes ($47 million; mostly Far North and Lockyer/Fassifern; 5% of Australia's production)
- lettuce ($43 million; mostly southern Queensland; 18% of Australia's production)
- french beans ($32 million; widely grown in Burdekin, Bowen/Mackay, Wide Bay, South Coast, Lockyer/Fassifern; 38% of Australia's production).

Another 8 vegetable crops are worth more than $10 million per annum at the farm gate, and a total of 27 vegetable crops are worth more than $1 million per annum at the farm gate (ABS 2004).

The major vegetable growing regions have traditionally been associated with major crops in certain seasons.

Atherton Tableland in the Far North is a major red soil potato production area, with significant sweetpotato and heavy cucurbit growing. The dry tropical coast produces large volumes of solanaceous (tomato, capsicum, eggplant) and cucurbit (melons, watermelons, pumpkin) crops, with major sweet corn and french bean industries as well. [Note that in general where the category 'melons' is used in this report, 'rockmelons and honeydew' are understood, with watermelons as a separate category.]

Wide Bay (Bundaberg, Maryborough) is a diverse growing region, with many mixed farms growing all the solanaceous crops, small and large cucurbits and the most significant sweetpotato cropping area.

The South Coast and Lockyer–Fassifern is also diverse, with major leafy and heading vegetable industries, potato and onion growing sectors, sweet corn and french bean industries. Summer production of tomatoes and capsicums is important as well.

The western Darling Downs is a major melon producing area, with the Eastern Downs and Granite Belt specialising in warm season production of solanaceous and leafy and heading vegetables.

Major recent changes in the Queensland vegetable industry in recent years have been:

- In the major growing areas, growing enterprises have aggregated around large packing sheds, either through outright farm purchases, farm supply arrangements, or common marketing arrangements. Production for many crops is often centred around 5 to 10 major growers in a region.
- Many major suppliers are selling by contract arrangement either to wholesalers or directly to retailers and retail chains. These contracts are often in place before planting, although there may or may not be a price negotiated in the contract.
- Many growers are concentrating on producing a few major crops, and investing heavily in mechanisation and handling equipment tailored for those crops. This specialisation means there is little flexibility for these large growers to change crops grown.
- Specialist niche markets (e.g. organic buyers, community or farmer markets, roadside stalls) have become significant outlets for many smaller peri-urban growers and production areas.

With the exception of the Burdekin, and to a lesser extent the Far North and South Coast regions, all areas have suffered severe water shortages in the last 5 years that constrained production. In response, growers have reduced plantings, and concentrated on their principal crops to ensure continuity of supply chains. The reduced plantings have been compensated for by higher returns in some instances. Vegetable growers have also responded by changing to more capital intensive and efficient irrigation infrastructure, such as drip irrigation of lettuce and sweet corn. They have constructed small storage dams which they fill using small submersible pumps operating 24 hours a day, and then double pump the accumulated water volumes onto crops. Some larger growers have also shifted production to other areas within Queensland or even interstate, such as sweet corn to fill supply gaps grown under contract in Tenterfield, NSW.

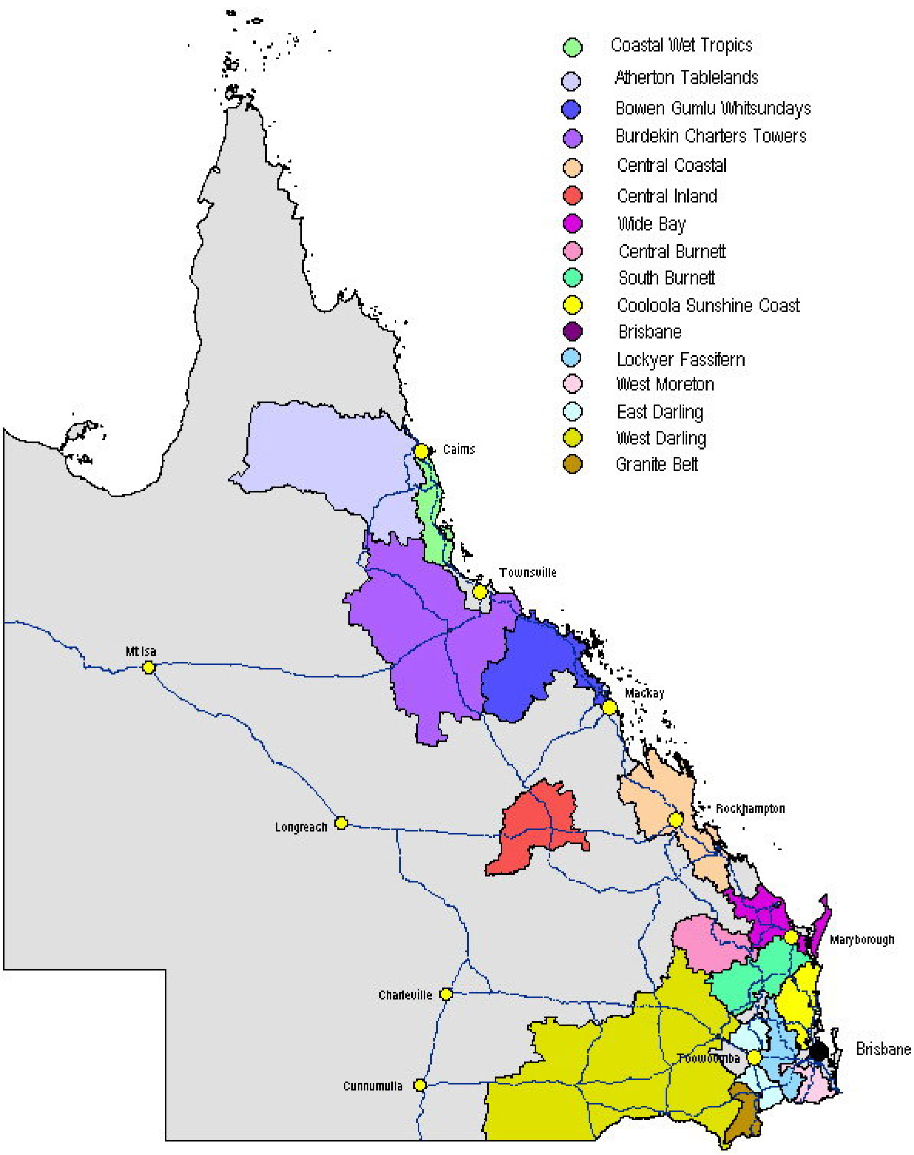
REGIONAL BOUNDARIES FOR THIS REPORT

The vegetable irrigation regions described in this report use the growing areas delineated in the HAL and Growcom funded consultancy report *Economic contribution of horticulture industries to the Queensland & Australian economies* (CDI Pinnacle Management and Street Ryan & Associates 2004), combining a small number of areas where there is minimal commercial vegetable-producing activity. The areas that the HAL and Growcom report delineates are preferable to those created by the ABS Statistical Divisions, which combine very disparate production areas, with very different irrigation issues: for example, in 2001, the Northern Statistical Division combined production from the Burdekin, which has a virtually unlimited water supply, with Bowen, which has a very limited and restrictive water supply.

In order to use the vegetable production statistics provided as part of the current HAL project, the author of this report undertook significant data manipulation to arrive at data for each of the vegetable irrigation regions. For each region, the author extracted, allocated and combined percentages of the crop within and between statistical local areas, with the percentage depending on various crops. For example, tomato production in the Burdekin was calculated as 4% of Northern SD and in Bowen–Mackay as 96% of Northern SD plus Mackay, whilst for melons, Burdekin was 44% of Northern SD, whilst Bowen–Mackay was 56% of Northern SD plus Mackay SD. These allocations were based on discussions with local horticultural professionals in each of the affected regions, who in turn used local statistics such as seedling production, transport values, and package supplies to arrive at their relative estimates.

The derivation and association between the production area definitions in this report, in the HAL and Growcom report, and ABS Divisions, are shown in Table 1 and Figure 1.

Figure 1 – Queensland horticultural growing areas



Source: CDI Pinnacle Management and Street Ryan & Associates 2004

Table 1 – Inter-association of vegetable production region delineations

Region	Queensland horticultural growing areas [a]	Statistical local area compilation [a]	ABS SD region [b]
Far North	Coastal Wet Tropics, Atherton Tablelands	Douglas, Cairns-Barron, Cairns Northern Suburbs, Cairns Part B, Johnstone, Cardwell, Hinchinbrook ex-Palm Island, Mareeba, Atherton, Herberton, Eacham	Far North, North West
Burdekin	Burdekin, Charters Towers	Burdekin, Dalrymple	Northern (percentage or all, depending on crop)
Bowen–Mackay	Bowen–Gumlu–Whitsundays	Bowen, Whitsunday, Mackay Part B	Mackay (plus percentage of Northern, depending on crop)
Central	Central Coast, Central Inland	Calliope Parts A&B, Fitzroy Parts A&B, Livingstone, Emerald, Peak Downs	Fitzroy, Central West
Wide Bay	Wide Bay	Burnett Parts A&B, Biggenden, Isis, Hervey Bay Parts A&B, Kolan, Maryborough	Wide Bay – Burnett (percentage depends on crop)
Upper Burnett	Central Burnett, South Burnett	Mundubbera, Gayndah, Wondai, Kilkivan, Kingaroy, Murgon, Tiaro, Woocoo	Wide Bay – Burnett (percentage depends on crop)
South Coast	Cooloola – Sunshine Coast, Brisbane, West Moreton	Cooloola ex-Gympie, Noosa Bal, Maroochy Bal, Maroochy-Buderim, Maroochy Bal in SC SSD, Caloundra Hinterland, Caloundra Rail Corridor, Caboolture Part B, Caboolture Bal in BSD, Kilcoy, Pine Rivers Shire Bal, Greenbank, Durack, Rochedale, Eight Mile Plains, Inala, Richland, Pallara, Heathwood, Larrapinta, Wishart, Beaudesert Parts A&B, Ipswich South West, Guanaba-Currumbin Valley	Brisbane and part of Moreton (percentage depends on crop)
Lockyer – Fassifern	Lockyer – Fassifern	Boonah, Ipswich West, Gatton, Laidley, Esk	Part of Moreton (percentage depends on crop)
Darling Downs	Eastern Darling Downs, Western Darling Downs	Crows Nest, Rosalie Parts A&B, Jondaryan Part A, Cambooya Part A, Clifton, Warwick East, Warwick north, Balonne, Chinchilla, Inglewood, Millmerran, Murilla, Paroo, Tara, Warroo, Wambo, Waggamba	Darling Downs (except Granite Belt - (percentage depends on crop)
Granite Belt	Granite Belt	Stanthorpe, Warwick West	Darling Downs (percentage depends on crop)

[a] CDI Pinnacle Management and Street Ryan & Associates 2004

[b] Australian Bureau of Statistics Statistical Division region

STATE-WIDE TRENDS IN THE VEGETABLE INDUSTRIES

In common with the rest of the Australian vegetable industries, the Queensland sectors are currently in a state of rapid flux. The changes are due to price and market issues associated with the potential and current availability of imported vegetables to compete with Australian production. This international competition has already savaged many Australian export markets, and is currently affecting the processed vegetable sector on the domestic market. The situation is the subject of several national industry reviews, by both government and industry representative bodies such as AUSVEG.

Changes to water supplies and regulations

Water supply and regulatory reform is also greatly affecting vegetable production sectors in several ways. In Queensland, there are concerns about access to water supplies for vegetable irrigation, and particularly the costs and regulatory hurdles associated with accessing secure supplies. Producer organisations and companies such as Growcom, Queensland Farmers Federation and AgForce Queensland are vigorously communicating their thoughts with governments, regulatory authorities and water supply agencies, as are individual producers.

Drought and depleted water reserves (surface and groundwater) are affecting vegetable irrigation and production in many areas. As water becomes more expensive to procure, sometimes of lower quality, and supply is increasingly limiting production, good management becomes a much greater imperative. This has been the catalyst for positive changes in improving water use efficiency, but severe water shortages can lead to despair and reduce the psychological capacity of producers to cope with change.

Vegetable industries in Queensland are a very significant component of overall primary production, and are valued by governments. They are perceived as industries deserving of targeted research and development support, hence a recent significant funding commitment by the Queensland Government to DPI&F efforts in this sector.

Government perception and promotion

As an industry sector with high cash turnover, vegetable production is perceived to have a competitive advantage over other primary industries in its capacity to pay for scarce water resources. Whilst in many instances this competitive advantage is real, there is also the downside that vegetable production is advocated by governments and water suppliers as an effective way to improve economic water use efficiency, e.g. (Wylie 2005). The obvious risk is that having more production of vegetables to achieve 'high returns per megalitre' could be self-defeating in a precarious and often over-supplied domestic market. There are ongoing instances of significant over-production of certain vegetable commodities, both from current producers seeking economies of scale, or new producers seeking returns on water investment, persuaded by the mantra of 'high value crops, with high returns per megalitre'.

In its latest Prospects analysis of the Queensland vegetable industries (Department of Primary Industries and Fisheries 2005), the following issues were highlighted:

- The new Burnett Water infrastructure (including the 300 000 ML Burnett Dam) will markedly increase water security for one of Queensland's prime vegetable growing regions.
- Vegetable industries will recover in 2005–06, associated with increases in price received rather than in production volumes, which are anticipated to fall.

- There will be ongoing rationalisation of participants across a range of industries, with the particular examples of tomatoes, capsicums and lettuce. The producers remaining in the industry will be those who are skilled at supply chain development. This does not necessarily mean direct links to supermarket chains, but may also be about supplying vegetables through niche markets (e.g. farmer markets). The emphasis is on relationship and business development, not on growing a specific crop.
- There will also be shifts in production to more water-secure regions (e.g. green beans from the Lockyer to Bundaberg and Bowen (and potentially the Burdekin).

Vegetable production at the crossroads

In his presentation to the AUSVEG summit in June 2005, Dr David McKinna made the following points about the Australian vegetable industries (McKinna 2005), most of which are certainly pertinent to Queensland. (McKinna's points are in italics; companion points by this report author are occasionally added.)

- *Less than 25% of current vegetable growers will still be producing by 2010, due to declining world competitiveness, declining margins, increasing land values, and* **cost and availability of water**. [Many Queensland vegetable industries have already undergone massive rationalisation; in many sectors, such as tomatoes, capsicums, celery, lettuce, and sweet corn, more than 85% of the state production comes from 5 to 10 producers.]
- *Fresh and value-added vegetable products are growing markets; processed product markets are at best flat.* [Queensland has already lost many traditional processing sectors and companies. One major company remains contracting, with only beetroot, sweet corn and green beans of national significance.]
- *Export opportunities are increasingly difficult, with strong competition from the 'New World', disadvantaged freight routes and narrowing windows of opportunity.* [Many Queensland vegetable producers with a tradition of exporting no longer supply significant volumes for export; rather, they have turned to domestic value-adding opportunities, or contracted supply chains.]
- *Key drivers for vegetable consumers in priority order (determined by actual purchasing behaviour, not professed attitudes) are:*
  - *taste and enjoyment*
  - *availability*
  - *price or value*
  - *nutritional value*
  - *convenience*
  - *safety.*

McKinna suggests that, by 2010:

- *The majority of commodity vegetables will be imported.*
- *Water-intensive, relatively low value vegetables* [his example is potatoes] *will be uncompetitive.* [Queensland is well placed, with many of its vegetable commodities having relatively high unit prices and a flavour-oriented consumer appeal e.g. tomato, capsicum, melons, sweet corn, and sweet/mild onion, and with water use in the lower ranges.]
- *Processing will move offshore.*

- *There will be strong domestic focus growth in categories where Australia has advantage (beetroot, onions, sweet corn).* [Queensland has a strong presence in many of these categories.]
- *We will continue to see the growth of large corporate and family business farms and ongoing growth of value-added sectors through strategic alliances with supply chain companies.* [Many Queensland vegetable sectors are already dominated by a few key family or corporate structures, with large scale production across several regions and climate zones.]
- *Ongoing growth of niche market chains* [his examples are organics, minimal chemical produce, farmer market supplies. Niche market chains are already strongly represented in many of Queensland's metropolitan and regional centres, allied with coastal and subcoastal tourism hubs and decentralised populations.]
- *Australia will export vegetable growing technology and systems to the 'New World'.*

McKinna suggests that the Australian vegetable industries agenda for the future should include:

- *cost reduction (particularly labour component)*
- *delivering consumer satisfaction*
- *obvious product differentiation (taste/enjoyment, nutrition, functionality, convenience, value).*

REGIONAL TRENDS IN VEGETABLE PRODUCTION

This section summarises the regional findings from the HAL and Growcom funded report *Economic contribution of horticulture industries to the Queensland & Australian economies* (CDI Pinnacle Management and Street Ryan & Associates 2004), with additional comments where pertinent.

Farm scale and enterprise structure

Large, specialist producers: Much of Queensland's vegetable production comes from large scale producers specialising in a few crops. These producers are commonly found in the major production regions of Bowen, Burdekin, Wide Bay, Lockyer–Fassifern, Granite Belt and Darling Downs.

They are the producers remaining after significant and ongoing rationalisation of production, particularly in the major commodity supply chains such as tomato, capsicum, sweet corn, green beans, and lettuce. In regions dominated by this process, average farm sizes tend to be markedly increasing, e.g. 58 ha in Bowen, 33 ha in Lockyer–Fassifern, 60 ha in Western Darling Downs. In areas where these larger producers are located, there is currently still a wide diversity of businesses, ranging from small family farms, to businesses with more than $40 million per annum turnover.

In recent years, there has been a substantial trend for the larger producers to diversify their production areas, e.g. moving to Wide Bay, Bowen, Darling Downs, or Granite Belt to cover different production windows, or Burdekin or Upper Burnett to access more secure water sources.

Not all large specialist farms are located in the principal vegetable growing regions. For example, one of Australia's largest sweetpotato growers is located on the Central Coast, just

Large corporate and family business farms will continue to dominate some sectors.

north of Rockhampton. The largest producer of hand-picked green beans is in the Gympie area of the South Coast region

Highly diversified or niche producers: Some vegetable producers seek to cover risk by producing a diverse range of vegetables, changing proportions of the mix to suit emerging market opportunities, or alternatively climatic conditions. This approach is common in the smaller production regions, such as Central, Upper Burnett, and South Coast. Interestingly, this diverse production is still relatively common in the Wide Bay region, even though it has also been the centre for a large amount of consolidation and specialisation in crops such as tomatoes and capsicums.

Other producers seek diversity by undertaking other forms of primary production, such as sugar, broadacre cropping or livestock production, particularly common in the Upper Burnett, West Moreton area of the South Coast, and the Darling Downs. They may grow a consistent volume of vegetables each year, or move in and out of the vegetable industry depending on weather conditions, vegetable prices or perceived opportunities, or prices for their other commodities, such as beef or sugar.

Until recently, the vegetable–sugar mix was very common in the Burdekin. The situation has changed in the past few years with the move of a few big Queensland producers to the region chasing reliable water supplies.

Another form of enterprise is the smaller niche producers, for example Far North Coastal specialist production of Pacific–SE Asian type vegetables (cassava, taro); Asian vegetables and mushrooms in the Brisbane urban fringe.

These niche and diverse producers tend to produce smaller areas of vegetables, often in the range of 10–23 ha per annum.

The exceptions are the diversified producers in the Western Darling Downs, where they are very large scale enterprises. These businesses tend to also invest in regional service industries, see horticulture as a diversification opportunity, and are already established in the area, rather than moving in from traditional vegetable growing areas.

Water availability and WUE

Water availability for irrigation has not to date been an issue in several production areas, including the Far North Coast, Burdekin, and southern areas of Upper Burnett. Even in these circumstances, however, there are still major concerns about regulation and price of water.

In other regions, e.g. Bowen–Gumlu, Central, Wide Bay, Upper Burnett, and South Coast, lack of water availability and security for irrigation can and does limit production. In areas such as the Lockyer Fassifern, Darling Downs and Granite Belt, the availability of water is considered critical. In some areas (e.g. South Coast), producers have even resorted to using high-cost reticulated town water for irrigation to maintain production levels.

In these regions, developments of new water sources (e.g. development of Elliot Main Channel, pipeline or Urannah Dam project in the Bowen region; recycled water to the Lockyer and Eastern Downs) are strongly promoted, with extensive seeking of collaborative support, but have not yet been implemented.

Vegetable growers are accessing and mixing water from surface and underground sources, often of variable quality and quantity, to meet their irrigation needs. This occurs where there is no large irrigation scheme or dominant water source such as a major alluvial aquifer, common in the Central, Upper Burnett, South Coast, Darling Downs and Granite Belt regions.

Some regions have concerns that current water supplies will be diverted away from vegetable irrigation to service other primary industries (e.g. sugar cane in the Far North, Wide Bay, wine grapes in the Granite Belt, broad acre cropping or livestock in the south of Upper Burnett and eastern Darling Downs); or other non-primary industries (e.g. tourism on the Atherton Tableland, South Coast; electricity generation and industry in Lockyer Fassifern), or just local population growth (South Coast, Lockyer–Fassifern.

Most regions expressed concerns about the increased regulation and price for water by local water supply schemes, as well as statewide agencies such as the Department of Natural Resources and Mines or SunWater. There are also concerns about the regulatory and pricing structures that may be associated with any new irrigation water supply infrastructure, particularly in Bowen, the new Burnett Dam in the Wide Bay–Upper Burnett regions, and new water storage scheme in the Granite Belt.

Water use efficiency: Vegetable production, through the use of high-tech systems such as drip tape (Bowen, Wide Bay, Lockyer/Fassifern, Granite Belt, specific crops in the Western Darling Downs) or centre pivots (Burdekin) is seen as a highly efficient use of irrigation water. In other regions, irrigation water use is not identified as being as efficient, due to reliance on older systems, and lack of scheduling practices.

In some regions, even though there may have been significant numbers of producers switch to new systems such as drip irrigation, because changes were not backed up by improved irrigation practice, advances in water use efficiency have only been moderate (e.g. Central, Upper Burnett region, South Coast). This emphasises the need for a systematic approach to improving water use efficiency, rather than assume that a simple single solution exists.

Labour issues

Access to labour is a common issue across all Queensland's vegetable growing regions. Some growing areas on the 'tourist trail', such as Bowen, Wide Bay, South Coast, and Granite Belt, can source backpackers seeking income, but even in these situations, producers express concerns about the skills, complexity of hire, and availability during peak periods.

Other areas, such as Burdekin, Central, Upper Burnett, and Darling Downs, which are not perceived as prime holiday destinations, are very concerned about access to sufficient labour, particularly during peak and critical periods. One approach is the development of the 'harvest trail' concept, which has some success in areas such as Emerald, in the Central region.

On the Darling Downs, in particular, there is emphasis on crops with a lower labour requirement, or crops that can be mechanised to a significant degree.

Even in urban areas such as the South Coast or Lockyer/Fassifern, with a permanent local labour resource, the supply of willing field operatives continues to decline.

In some regions, such as Wide Bay and Lockyer–Fassifern, there is widespread use of contractors to organise, train and supply adequate labour. In other regions, producers who have relocated from other areas bring their labour force with them, e.g. Upper Burnett.

Industry organisations, including local producer groups (e.g. Lockyer Alliance) and Growcom PL, are advocating schemes to improve labour access, such as visas for overseas workers, or 'FarmReady' certification, to improve labour accessibility promoting.

Access to labour is specifically identified as a threat to industry viability in most Queensland vegetable growing regions. In Central and North Queensland, competition from mining industries, offering significant salary packages for semi-skilled employees, is aggravating labour shortages.

Industries are seeking mechanisation and technology solutions to reduce their dependence on labour and to try and increase competitiveness with low labour cost countries. A current lack of technology development is often quoted as a major future concern from vegetable growers.

Transport issues

Some regions (e.g. far North, Burdekin, Bowen, Central, and Upper Burnett) indicate that distance from raw materials and markets causes difficulties with servicing major customers and issues with competitiveness due to freight costs.

In general, transport services are highly regarded, although they can become stretched during peak periods, particularly from high volume areas such as Bowen, Wide Bay, and Western Darling Downs. Some businesses, particularly in the Granite Belt and Lockyer regions, have invested in their own transport fleets to address this issue.

Larger growers, particularly from Bowen, Wide Bay, South Coast, Darling Downs and Granite Belt, also express concern about access to sea or air freight, indicating an export market intent or focus.

Some newer production areas have expressed concern about the availability and standard of cool chain transport, e.g. in the South Burnett area.

Business skills and development

Most of Queensland's vegetable growing regions report little development of business skills or mentoring amongst vegetable producers, except for Wide Bay and Granite Belt regions.

Most regions report relatively low education levels by producers. Exceptions are Bowen, Wide Bay, South Coast, Lockyer–Fassifern and Granite Belt where a significant proportion of growers under 40 years of age report formal business or horticultural qualifications. Many producers did not see low levels of education as an impediment to business success.

Some vegetable-growing regions such as Burdekin, Central, Wide Bay, South Coast, Lockyer–Fassifern, Darling Downs, and Granite Belt are serviced by tertiary and training institutions, but in other regions (e.g. Bowen, Upper Burnett) there are few or no postsecondary facilities.

Marketing approaches

Smaller growers, either diverse cropping or niche producers, often have a 'cottage industry' approach to products and marketing, selling directly to local shops or through farmers markets. These products can be raw or in some cases minimally processed materials. This enterprise approach is more common close to major regional centres and particularly tourist areas such as the far north Coast or Granite Belt. It also applies in the smaller production regions, such as the Upper Burnett and South Coast, where the scale of operations inhibits industrial value-adding opportunities.

Regions such as Far North, South Coast and Granite Belt have potential to align vegetable growing with tourism ventures and infrastructure.

Most regions report limited awareness or investment in value adding, with a strong focus on supplying fresh market commodities. Some businesses, such as onion and potato growers, or producers on the Darling Downs, are providing retail-ready packaging or minimally processed packages. Other businesses supply ingredients for up-chain food businesses. In the main production regions (e.g. Bowen, Wide Bay, Lockyer–Fassifern, and Granite Belt) there is investment in up-chain processing, mostly supplying raw ingredients to other food product mixes. Some of these businesses are of a national scale, but may not be cost-competitive globally.

Specialist growers producing high volumes of crop also tend to have good alliances up the supply chain, with direct access to major retail chains, whereas growers with little supply chain integration tend to be more diverse, to spread risks.

There have been significant grower alliances to increase marketing and purchasing power, in the Far North, South Coast, Lockyer–Fassifern, and Darling Downs regions, but in general these examples are relatively rare.

Throughout most of Queensland, there is generally little development of consolidation networks in horticulture. Exceptions are in the Wide Bay, South Coast, Lockyer–Fassifern, and to a lesser extent Darling Downs, where they have been supported by industry and government initiatives, but principally driven by a few large, successful producer businesses.

Vegetable producers from some regions (e.g. Central, Upper Burnett, Darling Downs and Granite Belt) are concerned that a lack of regional 'image' or presence as a major vegetable region, as well as small scale production, inhibits their capacity to enter and retain domestic market access. They are unsure whether they can compete with alliances of growers from other regions that establish firm supply chain relationships through volume production.

There is evidence in some crops that major retailers are preferentially sourcing produce (e.g. potatoes, onions, summer french beans) from southern states of Australia, reducing demand for Queensland produce. In response, several Queensland producers are purchasing or establishing production units in those southern districts (Jackson 2006).

Export effort

There is little regionally focussed export effort, either directly or through supply chains to exporters. Exceptions are tomatoes and melons to New Zealand, significant from the Burdekin, Bowen and Wide Bay regions, green beans to New Zealand from the South Coast, and brassicas and sweet corn to Asia from Lockyer–Fassifern. Some businesses on the Darling Downs have been specifically established with a strong export focus (e.g. brassicas and rockmelons into East Asia). One issue is what happens with product and these businesses during market downturns like the one we are currently experiencing.

Even in areas with some export effort, only a small proportion of the product departs for international markets: for example, less than 10% of Bowen or Wide Bay product is exported.

External impacts and sustainability issues

As other industries suffer market or price declines, there can be pressure to switch to vegetable production as an alternative. Interestingly, the decline in sugar prices has not seen a major increase in vegetable growing on the Atherton Tablelands, whereas it has been a substantial concern in the Wide Bay and South Coast region.

Urban encroachment and development of tourism infrastructure has been identified as having potentially major impact on vegetable production on the far North Coast, South Coast, and Lockyer–Fassifern. Other common allied concerns are cost of land, right to farm regulation, and general environmental compliance regulation.

Vegetable industries that are on catchments discharging into the Great Barrier Reef lagoon are going to have significant environmental compliance issues to deal with: regions such as Far North, Burdekin, Bowen, Central Coast and Wide Bay are particularly closely monitored.

Another important environmental issue that impacts on business sustainability is the disposal of plastic drip tape and mulch in the Burdekin, Bowen, Wide Bay and, to a lesser extent, the Central region.

Salinisation from over-pumping of aquifers, as well as potential sea water intrusion, is noted in the Burdekin, Bowen, Central Coast, and Wide Bay regions.

SECTION 2 – VEGETABLE PRODUCTION IN QUEENSLAND

The Queensland production area and volume, enterprise and irrigation volume information (Table 2) was principally sourced from the ABS data derived from 2001 figures (ABS 2004) supplied to the author of this report and crosschecked with information from the HAL and Growcom-initiated report *Economic contribution of horticulture industries to the Queensland & Australian economies* (CDI Pinnacle Management and Street Ryan & Associates 2004). Although there is some disparity in the regional distribution of the parameters, there is generally good overall agreement between the data sources.

Table 2 – Production, enterprises and irrigation water use in Qld vegetable regions

Data source	ABS data (ABS 2001; ABS 2004)		*Economic contribution* report (CDI Pinnacle Management and Street Ryan & Associates 2004)		Calculated data*
region	**vegetable production (t)**	**vegetable production area (ha) ABS**	***Econ contr.***	**vegetable enterprises**	**vegetable irrigation (estimated ML)**
Far North	56 341	2 423	3 079	132	8 702
Burdekin	52 729	2 777	2 012	57	8 462
Bowen–Mackay	101 926	5 504	5 782	100	16 558
Central	15 409	773	834	44	2 434
Wide Bay	108 506	5 355	4 069	182	14 069
Upper Burnett	8 442	559	776	40	2 370
South Coast	54 560	3 447	2 703	233	9 454
Lockyer–Fassifern	200 055	10 325	11 937	361	29 529
Darling Downs	48 305	2 982	2 616	103	9 503
Granite Belt	50 242	2 953	2 400	128	8 668
Total	696 515	37 098	37 648	1 380	109 750

* Data calculated from crop area data (ABS 2001; ABS 2004) and DPI&F benchmarked irrigation data (various DPI&F Agrilink publications, DPI&F Gross Margin spreadsheets, Water for Profit Fact sheets, personal communications)

The Queensland vegetable industry is decentralised, with 10 substantial growing regions from the southern border north to Cairns. Most production is in coastal or near-coastal valleys. Exceptions are the highland production areas of the Atherton Tableland in the Far North, and Granite Belt and Eastern Downs production areas close to the Queensland–NSW border. There is a specialist melon production area on the Western Darling Downs. Nearly 60% of the growing area, and 60% of the production volume, comes out of the Bowen, Bundaberg (Wide Bay) and Lockyer–Fassifern regions.

Although the state's average vegetable holding is around 26 ha, farms tend to be significantly larger in the Burdekin (38 ha), Bowen (58 ha), Lockyer–Fassifern (33 ha) and Western Darling Downs (60 ha) districts.

The volume of irrigation closely trends with production areas and volumes. Average irrigation per hectare is just under 3 ML/ha/crop, slightly higher in North Queensland, Upper Burnett and Western Downs, and lower (e.g. 2.7 ML/ha/crop) in the southern coastal production zones.

Vegetable production areas in Queensland have arisen from:

- **Historical development to service expanding urban areas**, as traditional vegetable growing regions disappeared with urban sprawl. Examples are the Lockyer–Fassifern and South Coast, utilising ground and surface waters initially developed for dairying and broadacre cropping.
- **Niche climates**. The eastern Darling Downs and Granite Belt initially expanded as vegetable suppliers during summer, when other regions were too hot for reliable production. Like most other areas, they have tended to push their production windows to try and achieve production economies of scale. Similarly, the Tablelands district of the Far North had production niches as well as access to newly developed irrigation infrastructure. Bowen–Mackay also developed to supply 'summer' vegetables such as tomatoes and capsicums to southern markets during winter.
- **Irrigation infrastructure**. Many vegetable areas developed in response to the provision of irrigation infrastructure, or development of groundwater resources, prime examples being Bowen, Atherton Tablelands, and Wide Bay. Initially the Burdekin irrigation scheme was focussed on sugar and some broadacre crops, although many Burdekin growers diversified in small crops as an alternative income stream.
- **Entrepreneurial producers**. Some significant vegetable-growing districts have come about because of large-scale investment by a few very large growers. Examples are brassica production on the Darling Downs, melons on the Western Downs, capsicums and melons in the Burdekin, and sweetpotato and potato in the Central region.
- **Diversification**. Some areas are expanding in production to give larger growers in traditional production areas diversity and security, e.g. sweet corn and beans in the Burdekin and Bowen areas by major Lockyer Valley growers, onion production onto the Darling Downs and even Upper Burnett. Traditional broadacre irrigators with access to more secure water supplies may also diversify into vegetables to take advantage of reduced production from water-deficient traditional areas. This is in conjunction with traditional growers, or independently.

ECONOMIC CONTRIBUTION OF VEGETABLE PRODUCTION

The 'Big 3' vegetable production regions (Bowen–Mackay, Wide Bay and Lockyer–Fassifern) between them produce over 60% by value of Queensland's vegetables, but there are $40 million to $70 million industries in the Burdekin–far North, South Coast, Darling Downs and Granite Belt regions (Table 3).

In most cases CDI Pinnacle Management and Street Ryan & Associates 2004 estimated that downstream industries and operations added another 100% of value on the farm gate contribution, giving a total industry worth to Queensland of 1.3 billion dollars per annum, and providing 13 500 jobs in regional Queensland.

This equates to $1.2 million of total vegetable regional output, and 12 regional jobs, for every 100 ML of irrigation water applied to vegetables.

The farm gate return for each ML of irrigation water applied to vegetables (Table 3) reflects the differences in regional crop mixes. For example, the high returns in Bowen and Wide Bay reflect a strong influence of tomatoes and capsicums, whilst lower values on the Atherton Tablelands are due to a concentration on potatoes and heavy cucurbits.

Table 3 – Vegetable production and value adding in Queensland vegetable regions

Data source	ABS data (ABS 2004)		*Economic contribution* report (CDI Pinnacle Management and Street Ryan & Associates 2004)			
Report region	**return on irrigation ($/ML)**	**production value ($ million)**		**value added ($ million)**	**regional output ($ million)**	**regional employment**
Far North	2945	25.6	33.1	29.6	62.5	746
Burdekin	5 190	43.9	21.6	19.8	41.6	462
Bowen–Mackay	7 187	119.0	131.9	79.4	250.3	2 389
Central	4 362	10.6	12.6	9.0	24.3	196
Wide Bay	8 951	125.9	109.3	108.9	207.6	2 643
Upper Burnett	4 370	10.4	7.3	7.5	14.0	177
South Coast	4 936	46.7	66.0	114.7	245.0	2 741
Lockyer–Fassifern	4 528	133.7	159.3	159.1	302.5	3 044
Darling Downs	3 438	32.7	48.1	39.1	91.3	467
Granite Belt	5 345	46.3	42.0	33.9	80.2	516
Total	5 420	594.8	640.8	601.1	1 319.3	13 381

VEGETABLE EXPORTS

Although there has been a strong push from the government to develop vegetable exports, overall volumes of product have tended to remain static or decline (Table 4).

Table 4 – Exports of selected top Queensland vegetable products, 2001/02 to 2004/05)

Product	2001/02 e Value ($)	2002/03 e Value ($)	2003/04 e Value ($)	2004/05 ee Value ($ fob)
Fresh melons (excl. watermelons)	7 872 029	8 707 841	7 648 621	8 329 948
Fresh or chilled tomatoes	3 412 977	6 261 431	7 127 338	5 986 316
Fresh or chilled broccoli	4 338 660	5 692 186	4 463 893	4 442 453
Fresh or chilled beans	1 964 190	1 916 033	2 352 870	
Fresh or chilled seed potatoes				2 162 184
Fresh or chilled Chinese cabbage	2 776 519	1 979 940	1 391 850	
Fresh or chilled asparagus	1 387 666	387 330	764 107	1 191 437
Fresh or chilled cauliflowers	2 350 734	1 798 634	1 253 931	1 096 793
Fresh or chilled carrots/turnips	2 203 246	2 437 792	1 659 396	1 092 157
Fresh watermelons				957 302
Tomatoes, whole or in pieces prepared or preserved				636 474
Frozen vegetables (excl. potatoes, leguminous, spinach and sweet corn)				324 626
Fresh or chilled onions	83 690	206 310	88 973	319 820
Single vegetable juice				316 505
Fresh or chilled potatoes (excl. seed)	180 851	365 163	670 767	302 579
Frozen mixed vegetables				259 016
Fresh or chilled cabbages				229 685
Frozen sweet corn				171 365
Sweet corn prepared or preserved				123 453
Mixed vegetable juice				116 025
Cucumbers and gherkins prepared or preserved by vinegar or acetic acid				88 494
Mushrooms				80 955
Fresh or chilled garlic				67 541

e Source: Office of Economic and Statistical Research and Queensland Treasury

ee Source: ABS Custom request International Merchandise Trade Statistics - Exports of vegetables by state

Generally, exports to Oceania (New Zealand and South Pacific island countries) have stayed constant, particularly tomatoes and capsicums, melons and french beans. Exports to South-East and East Asia have come under significant pressure from competition, particularly from China. Whilst broccoli is just holding ground, other commodity vegetables such as Chinese cabbage, cauliflowers and carrots have suffered losses of export market share. There are still some niche market export opportunities, such as seed potatoes into South-East Asia.

AREA PLANTED TO VEGETABLES

The diversity of vegetable production throughout Queensland can be seen by the fact that the top 5 crops by planted area make up less than 50% of the total area planted to vegetables (Table 5).

Table 5 – Major vegetable crops (by area) in Queensland vegetable growing regions

region	Total veg. prod. area (ha)	Crop 1	Crop 2	Crop 3	Crop 4	Crop 5	Cumulative % 5 major crops
Far North	2 423	potato 60%	pumpkin 20%	watermelon 7%	sweetpotato 4%	zucchini 2%	92%
Burdekin	2 777	pumpkin 26%	capsicum 12%	potato 11%	melons* 10%	watermelon 10%	69%
Bowen–Mackay	5 504	tomato 27%	french bean 21%	capsicum 15%	watermelon 10%	pumpkin 9%	82%
Central	773	watermelon 33%	pumpkin 21%	melons* 11%	sweetpotato 11%	zucchini 6%	81%
Wide Bay	5 355	zucchini 14%	sweetpotato 13%	tomato 11%	french bean 10%	potato 8%	57%
Upper Burnett	559	asparagus 37%	watermelon 19%	pumpkin 14%	tomato 11	zucchini 7%	88%
South Coast	3 447	potato 18%	french bean 15%	pumpkin 13%	lettuce 8%	zucchini 7%	60%
Lockyer–Fassifern	10 325	pumpkin 14%	sweet corn 14%	potato 13%	beetroot 9%	french bean 7%	57%
Darling Downs	2 982	watermelon 22%	melons* 15%	potato 14%	pumpkin 12%	lettuce 8%	72%
Granite Belt	2 953	broccoli 19%	lettuce 15%	cauliflower 14%	capsicum 10%	tomato 6%	64%
State total	37 089	potato 13%	pumpkin 12%	french bean 9%	watermelon 8%	tomato 7%	49%

Source: ABS 2004 * 'melons' includes rockmelons and honeydews, but excludes watermelons

Although a mature industry, potatoes are still a major planted area in Queensland, particularly in the traditional growing areas of the Atherton Tableland in the Far North region, as well as significant plantings in various southern Queensland regions.

The area planted to pumpkins is a surprise, but probably reflects the growing of pumpkins as an opportunity crop by other producers, e.g. mixed vegetable growers, sugar cane growers, and even grain growers and graziers who have areas of suitable alluvium or fortuitous rainfall. Of course, there are also people who concentrate on pumpkin production, including specialist varieties for segmented markets. The story is similar with watermelons, although, with the advent of new seedless varieties with more precise agronomic requirements, this may become a more specialised industry.

Because Queensland is the major producer of fresh market tomatoes and french beans, it is no surprise that there are significant plantings in the main production areas of Bowen, Wide Bay, South Coast and Lockyer–Fassifern.

The Far North region has the most concentrated vegetable production portfolio, with potatoes and heavy cucurbits making up nearly 90% of the vegetable area. The Burdekin region is more diverse, with solanaceous crops (capsicums, potatoes and eggfruit), and cucurbits (pumpkins, melons, and zucchinis and squash) predominant. There are also substantial plantings of sweet corn and some french beans: plantings of these two crops are increasing every time water shortages hit the Bowen district. Bowen and surrounding districts are major Australian producers of cool season tomatoes, capsicums, melons, watermelons, pumpkins, french beans and sweet corn, with those crops accounting for more than 85% of the planted area.

In the main, vegetable cropping in the Central and Upper Burnett are mainly mixed farms, many probably catering for local markets, or opportunistic cropping to supply central markets. Exceptions are a major sweetpotato producer in the Central Region, and significant asparagus production in the Upper Burnett.

Wide Bay is the most diverse vegetable cropping area in Queensland, with a mix of summer and winter vegetables nearly all year round, thanks to a moderate climate, good soils and, until recently, reasonably reliable water supplies. Small cucurbits (zucchini, cucumbers, squashes) and tomatoes are traditionally dominant vegetables, although the last 5 to 10 years has seen a major shift of sweetpotato production into the area, making it the dominant sweetpotato growing area in Australia.

The South Coast and Lockyer–Fassifern are also diverse vegetable areas, with significant plantings of potatoes, leafy and heading vegetables, and pumpkins. Most other vegetable crops are grown here at some time of the year. The Gympie area of the South Coast is a major supplier of hand-picked french beans, whilst much of Queensland's sweet corn, lettuce, onion, carrot, broccoli, beetroot, warm season capsicum and autumn–spring french bean crop is sourced from the Lockyer–Fassifern region.

The Eastern Downs has significant volumes of summer lettuce and celery, and some potatoes and onions, whilst the Western Darling Downs grows large areas of rockmelons, honeydews and watermelons. The Granite Belt is a major warm season production area for both leafy and heading vegetables (lettuce, brassicas, celery), as well as tomatoes and capsicums.

VALUE OF VEGETABLE CROPS

The value of the Queensland vegetable crop mix (Table 6) gives a different ranking of crops compared with area planted (Table 5), although the state-wide and regional diversity is still apparent.

Table 6 – Major vegetable crops (by value) in Queensland vegetable growing regions

region	Total veg. prod'n value ($M)	Crop 1	Crop 2	Crop 3	Crop 4	Crop 5	Cumulative % 5 major crops
Far North	25.6	Potato 67%	Sweetpotato 10%	Pumpkin 9%	Watermelon 6%	Tomato 2%	94%
Burdekin	43.9	Capsicum 25%	Melons* 12%	Eggplant 10%	Pumpkin 9%	Potato 8%	64%
Bowen–Mackay	119.0	Tomato 47%	Capsicum 22%	French bean 9%	Melons* 6%	Watermelon 6%	88%
Central	10.6	Watermelon 28%	Sweetpotato 24%	Melons* 22%	Pumpkin 9%	Cucumber 4%	88%
Wide Bay	125.9	Tomato 34%	Sweetpotato 16%	Capsicum 10	Zucchini 8%	Melons* 6%	74%
Upper Burnett	10.4	Tomato 46%	Asparagus 23%	Watermelon 10%	Capsicum 6%	Zucchini 5%	91%
South Coast	46.7	Lettuce 15%	Tomato 12%	French bean 12%	Potato 10%	Spring onion 8%	57%
Lockyer–Fassifern	133.7	Lettuce 16%	Tomato 13%	Sweet corn 10%	Potato 9%	Carrot 9%	56%
Darling Downs	32.7	Melons* 16%	Lettuce 15%	Watermelon 14%	Potato 11%	Onions 8%	64%
Granite Belt	46.3	Lettuce 19%	Capsicum 14%	Broccoli 14%	Tomato 11%	Cauliflower 8%	66%
State total	594.8	Tomato 23%	Capsicum 10%	Potato 8%	Lettuce 7%	French bean 5%	53%

Source: ABS 2004 * includes rockmelons and honeydews, excludes watermelons

Tomatoes and capsicums account for one-third of total vegetable value, with potatoes, lettuce and french beans accounting for another 20%.

Potato is by far the most valuable vegetable on the Atherton Tableland. The strong performance and price of sweetpotato in recent years has maintained the value of the relatively small planted areas of that crop in the Far North. Capsicums, melons and the niche crop of eggplant make up nearly 50% of vegetable value in the Burdekin Region. Vegetable value in Bowen–Mackay is nearly all accounted for by tomatoes, capsicums, french beans, melons, watermelons and sweet corn.

As previously stated, vegetable cropping in the Central and Upper Burnett are mainly mixed farms, with much value coming from watermelons, melons, cucurbits and capsicums. A large sweetpotato grower produces a significant proportion of the Central Region vegetable value, whilst asparagus is a significant industry in the Mundubbera area of the Upper Burnett.

Wide Bay gains a high proportion of its value from the nationally important tomato, capsicum, sweetpotato and small cucurbit industries; although another 25% of its vegetable value comes from other crops.

Lettuce is the most valuable individual crop south of Gympie (Table 6), with tomatoes and potatoes also traditionally important in three of the four southern regions. Other valuable crops on the South Coast, Lockyer–Fassifern, granite Belt and Eastern Darling Downs are sweet corn, french beans, brassica vegetables, onions, carrots and capsicums. Melons and watermelons are valuable vegetable crops on the Western Darling Downs.

Pumpkin and sweet corn are major users of irrigation water in Queensland.

VEGETABLE WATER USE BY REGION

Generally, regional vegetable irrigation (Table 7) correlates strongly with area of vegetables planted (Table 5).

Table 7 – Major vegetable crops (by water use) in Queensland vegetable growing regions

Region	Total vegetable irrigation (ML)	Crop 1	Crop 2	Crop 3	Crop 4	Crop 5	Cumulative % 5 major crops
Far North	8 702	potato 67%	pumpkin 14%	watermelon 6%	sweetpotato 3%	asparagus 2%	93%
Burdekin	8 464	pumpkin 21%	potato 14%	capsicum 12%	melons* 12%	watermelon 11%	70%
Bowen–Mackay	16 558	tomato 32%	capsicum 15%	french bean 14%	watermelon 12%	pumpkin 8%	80%
Central	2 434	watermelon 36%	pumpkin 16%	melons* 13%	sweetpotato 12%	potato 5%	83%
Wide Bay	14 069	sweetpotato 15%	tomato 14%	potato 10%	watermelon 9%	zucchini 8%	56%
Upper Burnett	2 370	asparagus 60%	watermelon 13%	tomato 9%	pumpkin 7%	zucchini 3%	92%
South Coast	9 454	potato 20%	french bean 11%	pumpkin 9%	lettuce 7%	asparagus 6%	53%
Lockyer–Fassifern	29 529	sweet corn 17%	potato 14%	pumpkin 10%	carrot 8%	beetroot 8%	56%
Darling Downs	9 503	watermelon 21%	melons* 14%	potato 14%	asparagus 12%	pumpkin 7%	68%
Granite Belt	8 668	broccoli 19%	cauliflower 17%	lettuce 13%	capsicum 9%	tomato 7%	64%
State total	109 750	potato 15%	pumpkin 9%	watermelon 9%	tomato 9%	sweet corn 7%	49%

Source: ABS 2004 * includes rockmelons and honeydews, excludes watermelons

Long season vegetables like asparagus use more water, and therefore have a greater relative ranking, whilst short-term crops such as french beans, or opportunistically grown and irrigated crops such as pumpkins, feature less strongly than their planted area would indicate.

Across the regions, Central and Upper Burnett have the least irrigation (around 2.5 GL each per annum), associated with relatively low planting areas, and, in the case of the

Central region, a preponderance of opportunistically grown and irrigated crops such as pumpkins and watermelons.

Each of the other regions, apart from the 'Big 3', use about 8.5–9.8 GL/annum, whilst Bowen–Mackay and Wide Bay use 14–17 GL/annum, and Lockyer–Fassifern nearly 30 GL each year.

Compared with sugar cane, cotton, and the groups of irrigated pastures and cereals, vegetable irrigation consumes about 5% of the state's irrigated production water use (Table 8). This does not include irrigation for home, parks or gardens.

Table 8 – Irrigated crops and pastures in Queensland, 2002-04

Irrigated crop or pasture	Total irrigation 2002/03 (ML)	Total irrigation 2003/04 (ML)	Major irrigation presence	Some irrigation presence
Sugar cane	1 212 802 54%	1 141 173 47%	Far North, Burdekin, Wide Bay,	Bowen–Mackay*, South Coast
Cotton	313 770 14%	456 802 19%	Darling Downs	Central, Upper Burnett
Pastures (grazing, seed, hay or silage)	232 019 10%	285 750 12%	Far North, Central, Upper Burnett, South Coast, Lockyer–Fassifern, Darling Downs	Wide Bay
Cereals	178 444 8%	216 538 9%	Far North, Upper Burnett, Darling Downs	Burdekin, Central, Wide Bay, South Coast, Lockyer–Fassifern
Fruit, nuts, plantation or berry fruit	125 713 6%	128 163 5%	Far North, Burdekin, Wide Bay, Upper Burnett, South Coast, Granite Belt	Lockyer–Fassifern, Darling Downs
Vegetables	110 644 5%	97 564 4%	All Qld vegetable regions	All Qld vegetable regions
Other broad-acre crops	32 542 1%	62 444 3%	Far North, Upper Burnett, Darling Downs	Central, Wide Bay, South Coast, Lockyer–Fassifern
Nurseries, cut flowers, cultivated turf	14 052 1%	15 030 1%	Far North, South Coast, Lockyer–Fassifern	Wide Bay, Granite Belt
Grapevines	8 291 <1%	9 599 <1%	Central, Upper Burnett, Granite Belt	South Coast, Darling Downs
State total	2 229 009	2 420 048		

Source: ABS 2005b

In the Far North, Burdekin, Wide Bay and Mackay (not Bowen) regions, sugar cane would be the dominant irrigated crop, with significant irrigation of cereals such as maize for grain and silage, and also fruit/nuts (mangoes, bananas and macadamias). The Far North also has extensive irrigated pastures for dairy and beef, and there are also some irrigated pastures in the Wide Bay region. In the Bowen district, there is a small amount of irrigation of fruit and of pastures and cereals for grazing or hay.

In the Central region, the major production uses of irrigation water are for irrigated pastures for beef and some dairy; cotton, grapes and citrus (until recently) around Emerald; and cereals and other broadacre crops. Similarly, pastures, cereals, fruit (mainly citrus), other broadacre crops (e.g. peanuts), and to a lesser extent cotton are significant users of the available irrigation water.

The South Coast is a very mixed production environment, with cotton the only irrigated crop, pasture or horticultural industry not represented.

Apart from vegetables, the major production irrigation uses in the Lockyer–Fassifern are pastures (lucerne for hay, improved pastures or lucerne for dairy or beef herds), with some areas of broadacre crop, fruit production, nursery, flower and turf industries.

The Darling Downs is a major cotton-growing area, but also has significant areas of irrigated pasture for dairy and beef production, irrigated cereals and legumes for human consumption and stock feed, with some grape (fresh and wine) production as well.

Apart from vegetables, the predominant irrigation water use on the Granite Belt is for deciduous fruit production, with a burgeoning wine industry, and some nursery and cut flower production.

FARM GATE VALUE OF VEGETABLES

The full ranked farm gate value of all vegetables of significance produced in Queensland is given in Table 9. The diversity of the Queensland industries is demonstrated by having 15 different crops worth more than $10 million per year, and 27 crops worth more than $1 million per year.

A total of 5 vegetable types (tomato, capsicum, potato, watermelon, pumpkin) are grown to values of more than $500 000 in each of 7 or more regions across Queensland. A further 11 vegetables (lettuce, french beans, sweetpotato, melons, sweet corn, broccoli, zucchini, cabbage, celery, cauliflower and cucumber) are valued at more than $500 000 in each of 4 to 6 growing regions across the state.

The most diverse regions are the South Coast and Lockyer–Fassifern, each with 20 to 21 different vegetable crops worth more than $500 000 per annum. The Burdekin, Wide Bay, Darling Downs and Granite Belt all have 13 to 15 vegetable types worth more than $500 000 per annum. The Bowen–Mackay region is more concentrated, having 9 crops with a farm gate value greater than $500 000 per year. With small overall production areas (Central and Upper Burnett), or a focus on one or two major vegetables (Far North), the remaining regions only have 4 or 5 vegetables worth more than $500 000 per year at the farm gate.

Table 9 – Farm gate value ($) of vegetables in Queensland

	Far North	Burdekin	Bowen–Mackay	Central	Wide Bay	Upper Burnett
Tomato	468 990	2 323 383	55 799 829	314 680	42 904 679	4 767 187
Capsicum	178 278	11 041 422	25 763 328	114 652	12 375 555	651 345
Potato	17 270 499	3 480 119	29 202	85 224	4 923 673	
Lettuce	5 170	508 936			103 000	11 444
French beans	13 122	1 415 774	10 382 345		5 927 705	
Watermelon	1 563 841	3 243 965	6 586 232	3 022 034	4 149 119	1 037 280
Sweetpotato	2 500 000	500 000		2 500 000	20 000 000	
Melons*		5 303 919	6 750 443	2 382 947	7 491 406	
Sweet corn	83 634	1 391 411	4 662 930	15 454	1 904 168	100 219
Pumpkins	2 331 370	4 108 280	2 873 495	976 036	925 378	231 344
Broccoli				1 371	8 032	
Zucchini	226 430	1 274 930	475 901	301 870	10 097 419	531 443
Carrot	3 461			59 963	55 310	6 146
Eggplant		4 200 000	3 500 000		4 300 000	
Onion	293 447	9 153		161 094	234 563	234 563
Cabbage	306 273		37 227	63 346	38 528	
Celery						
Beetroot	60 997					
Cauliflower				16 294	17 083	
Snow peas					5 955 534	
Cucumber	273 339	1 772 779	389 147	424 472	1 281 477	67 446
Spring onion						
Asparagus				5 490	127 614	2 424 659
Melons nec	40 621	2 524 747	1 558 663		765 787	191 447
Chinese cabbage						
Marrows and squashes		829 788	182 148	146 383	1 936 567	101 925
Parsley				26 915	24 578	
Leeks						
French beans (processing)						
Green peas (processing)						
Parsnips						
Swedes						
Brussels sprouts						

	South Coast	Lockyer–Fassifern	Darling Downs	Granite Belt	State total
Tomato	5 729 618	17 284 673		5 086 310	134 679 348
Capsicum	1 098 025	1 679 273		6 554 013	59 455 891
Potato	4 853 830	11 449 682	3 747 714	936 928	46 776 871
Lettuce	6 982 230	21 454 468	4 842 296	8 992 836	42 900 380
French beans	5 420 364	8 081 656		841 497	32 082 463
Watermelon	603 873	3 779 129	4 451 533	494 095	28 931 101
Sweetpotato	3 000 000	250 000			28 750 000
Melons*	271 742	181 161	5 385 522	549 059	28 316 199
Sweet corn	838 431	13 151 098	1 515 949	378 987	24 042 281
Pumpkins	1 895 740	5 692 805	1 278 118	311 800	20 624 366
Broccoli	1 453 740	7 763 535	2 098 600	6 295 799	17 621 076
Zucchini	1 963 010	503 410		1 555 417	16 929 830
Carrot	1 379 875	11 412 571	1 056 598	264 150	14 238 073
Eggplant					12 000 000
Onion	218 097	8 163 184	2 485 497	130 816	11 930 413
Cabbage	1 976 565	3 466 442	656 536	2 626 142	9 171 059
Celery	739 738	2 148 173	2 167 973	3 251 960	8 307 844
Beetroot	564 027	7 593 475		9 173	8 227 672
Cauliflower	570 532	2 263 190	631 665	3 579 436	7 078 200
Snow peas	50 252	66 325		700 562	6 772 673
Cucumber	708 695	1 093 992		264 036	6 275 383
Spring onion	3 604 570	2 302 473	17 621	17 621	5 942 285
Asparagus	934 720	233 680	1 976 765		5 702 928
Melons nec	88 838	318 191	81 242	18 034	5 587 570
Chinese cabbage	1 065 073	2 186 903		2 050 027	5 302 003
Marrows and squashes	28 620	112 650		143 707	3 481 788
Parsley	599 171		279 584	279 584	1 209 832
Leeks	18 770	18 532		911 376	948 678
French beans (processing)		547 896		2 487	550 383
Green peas (processing)		380 513			380 513
Parsnips		88 209			88 209
Swedes		36 142		28 766	64 908
Brussels sprouts			38 966		38 966

CLIMATES OF QUEENSLAND VEGETABLE GROWING REGIONS

The climatic values in Table 10 and Table 11 have been derived from Bureau of Meteorology (BOM) climate averages, and by crosschecking tabulated evaporation with BOM evaporation maps. **Shaded cells** show the region's main vegetable growing season.

Table 10 – Average seasonal rainfall (mm) for Qld vegetable growing regions

Region	Representative town	Summer (Dec–Feb)	Autumn (March–May)	Winter (June–Aug)	Spring (Sept–Nov)	Total
Far North	Mareeba	557	246	29	76	908
Burdekin	Composite of Townsville and Ayr	627	279	52	92	1 050
Bowen–Mackay	Bowen	581	250	76	73	980
Central	Rockhampton	438	202	110	139	890
Wide Bay	Bundaberg	494	277	143	189	1 102
Upper Burnett	Kingaroy	321	166	112	181	780
South Coast	Brisbane	450	310	171	219	1 149
Lockyer–Fassifern	Gatton	313	181	106	180	780
Darling Downs	Composite of Dalby and Miles	259	137	107	161	665
Granite Belt	Stanthorpe	278	160	139	196	772

Source: Bureau of Meteorology 2005

The Darling Downs, Granite Belt, Lockyer–Fassifern and Upper Burnett receive the least annual rainfall of the vegetable production districts (650–800 mm), whilst the districts from Wide Bay north receive 900–1100 mm per annum. The South Coast receives both the most rain (1150 mm), and the most evenly distributed rainfall across the year.

In the Wide Bay region, 70% of the rain falls in the 6 months December to May, with this summer–autumn dominance rising to 90% as you move into the northern regions. In all regions, winter is the driest period, followed by spring.

There is significant vegetable production all year round in the Far North, Wide Bay, South Coast and Lockyer–Fassifern regions. Vegetable growing is avoided in summer (due to excessive heat) in the Burdekin, Bowen–Mackay, Central and Upper Burnett regions, and in winter (due to frosts) in the Upper Burnett, Darling Downs and Granite Belt regions.

Table 11 – Average seasonal Class A pan evaporation (mm) for Qld vegetable growing regions

Region	Representative town	Summer (Dec–Feb)	Autumn (March–May)	Winter (June–Aug)	Spring (Sept–Nov)	Total
Far North	Mareeba	361 (490)*	282 (370)	236 (325)	419 (550)	1314 (1800)
Burdekin	composite of Townsville and Ayr	682	533	454	703	2380
Bowen–Mackay	Bowen	379 (480)	442 (410)	378 (360)	557 (590)	1687 (1800)
Central	Rockhampton	641	478	356	610	2081
Wide Bay	Bundaberg	635 (530)	439 (380)	319 (310)	546 (480)	1935 (1700)
Upper Burnett	Kingaroy	566	350	224	486	1606
South Coast	Brisbane	578	373	277	507	1733
Lockyer–Fassifern	Gatton	603	404	300	546	1844
Darling Downs	composite of Dalby and Miles	678	447	255	546	1931
Granite Belt	Stanthorpe	518	310	206	443	1497

Source: Bureau of Meteorology 2005

Shaded areas are the main vegetable growing season for the region.

* Values in brackets are indicative from BOM Australian evaporation maps, as weather records from station may be too short term.

In all of Queensland's vegetable producing regions, pan evaporation markedly exceeds rainfall on an annual and seasonal basis. This is generally more pronounced from Wide Bay north, because in these regions the main vegetable production is during the driest 9 months of the year.

In all regions except the Far North, Wide Bay and South Coast, pan evaporation exceeds rainfall by more than 200 mm in every 3-month interval during the main vegetable growing periods. In the Far North, Wide Bay and South Coast, the summers and autumns are more accommodating; with the difference between 50 to 150 mm for each of those 3-month periods. (The deficit is also only around 100 mm during the South Coast winter).

These dry production climates and substantial evaporation deficits reduce the risks to crop yields and quality from waterlogging or water-enhanced plant diseases. It also means that, without irrigation, profitable production is virtually impossible.

VEGETABLE CROP YIELDS

The difficulty in analysing yield performance of vegetable crops in Queensland becomes immediately apparent because of the disparity between different data sources. In Table 12, the yields derived from ABS production statistics are compared with DPI&F data, sourced from regional agronomic literature, best practice extension material, regional surveys, and extension officers' personal knowledge. Values in *italics* (**bm**) are generally from benchmarked 'best practice' demonstrations, where available.

Generally there is good agreement between the ABS statistics and DPI&F regional values for potato, sweetpotato, and overall Queensland tomato yields.

ABS-derived yields are 25% underestimates for tomato, capsicum, melons and beans in the Bowen and Burdekin area, tomato on the South Coast, and lettuce on the Darling Downs and Granite Belt. It appears ABS-derived yields are 50% underestimates for pumpkins in the Far North, capsicums in Wide Bay, french beans on the South Coast, melons and watermelons on the Darling Downs and capsicum on the Granite Belt.

For many crops, benchmarked best practice yields achieved by commercial growers are significantly higher again than the regional yield values, indicating room for substantial regional improvement in productivity.

Table 12 – Yields (t/ha) of major crops (by value) in Queensland vegetable growing regions

Region	Crop 1	ABS[c]	DPI&F[d]	*bm*	Crop 2	ABS	DPI&F	*bm*	Crop 3	ABS	DPI&F	*bm*
Far North	Potato	29.4	30[f]	*40*[g]	Sweetpotato	26.7	26.6[h]		Pumpkin	11.5	25[i]	
Burdekin	Capsicum	19.9	25[i]	*32-40*[j]	Melons*	20.6	25[i]		Eggplant	35.0		
Bowen–Mackay	Tomato	27.6	40[i]	*60-90*[g]	Capsicum	19.8	25[i]	*32-40*[j]	French bean	4.2	5[i]	
Central	Watermelon	25.7	21.5[k]		Sweetpotato	26.7	26.6[h]		Melons*	29.8	29.8[k]	
Wide Bay	Tomato	55.4	53[k]	*60-90*[g]	Sweetpotato	26.6	26.6[h]		Capsicum	17.3	35[k]	*32-40*[j]
Upper Burnett	Tomato	55.4	40[k]	*60-90*[g]	Asparagus	2.6			Watermelon	21.3	21.5[k]	
South Coast	Lettuce	28.2	30[l]	*35-40*[g]	Tomato	29.7	40[k]	*60-90*[g]	French bean	5.0	8[g]	
Lockyer–Fassifern	Lettuce	33.0	30[l]	*35-40*[g]	Tomato	95.6	40[k]	*60-90*[g]	Sweet corn	10.3	11[m]	*15-20*[g]
Darling Downs	Melons*	13.0	25[n]		Lettuce	23.0	30[l]	*35-40*[g]	Watermelon	14.3	30[g]	
Granite Belt	Lettuce	23.0	30[l]	*35-40*[g]	Capsicum	13.4	25[g]	*32-40*[j]	Broccoli	6.7		
State average	Tomato	37.4	40[i]	*60-90*[g]	Capsicum	18.0	25[g]	*32-40*[j]	Potato	24.3	25-30[f]	*35-40*[g]

* includes rockmelons and honeydews, but excludes watermelons
c ABS 2004
d various DPI&F Agrilink publications, DPI&F Gross Margin spreadsheets, Water for Profit Fact sheets, personal communications
f Potato Agrilink g Water for Profit Fact sheets h Eric Coleman, pers.comm. i Des McGrath, pers. comm.
j Capsicum Agrilink k Jerry Lovatt, pers. comm. l Lettuce Agrilink m DPI&F Gross Margins
n Rockmelon Agrilink

SECTION 3 – WATER USE IN THE QUEENSLAND VEGETABLE INDUSTRIES

AGRONOMIC WUE EFFICIENCY

Due to the disparity in yields described previously, it is difficult to determine how much of any difference in agronomic water use efficiency of crops between regions is real, or an artefact of the variability of the yield data. For example, this author feels it highly unlikely that Lockyer–Fassifern tomato growers achieve 27.3 t/ML of irrigation compared with 7.9 t/ML by Bowen tomato growers (Table 13). The following discussion places more credence on the DPI&F-derived estimates of crop agronomic WUE, where available.

Table 13 – Agronomic water use efficiency (t/ML) of major crops (by value) in Queensland vegetable growing regions

Region	Crop 1	ABS data [c]	From DPI&F sources [d]	Crop 2	ABS data	From DPI&F sources	Crop 3	ABS data	From DPI&F sources
Far North	Potato	7.3	8.7 g	Sweetpotato	7.6	7.6 h	Pumpkin	4.6	10.0 i
Burdekin	Capsicum	6.6	8.3 g	Melons*	5.9	7.1 g	Eggplant	8.8	
Bowen–Mackay	Tomato	7.9	10.0 i	Capsicum	6.6	8.3 g	French bean	2.1	2.5 g
Central	Watermelon	7.3	10.2 k	Sweetpotato	7.6	7.6 h	Melons*	8.5	8.5 g
Wide Bay	Tomato	15.8	10.0 k	Sweetpotato	8.9	8.9 h	Capsicum	6.9	11.7 k
Upper Burnett	Tomato	15.8	10.0 k	Asparagus	0.4		Watermelon	7.1	10.2 k
South Coast	Lettuce	11.3	12.0 g	Tomato	8.5	10.0 k	French bean	2.5	4.0 g
Lockyer–Fassifern	Lettuce	13.2	12.0 g	Tomato	27.3	10.0 k	Sweet corn	3.0	3.1 m
Darling Downs	Melons*	4.3	8.3 g	Lettuce	9.2	12.0 g	Watermelon	4.8	15.0 g
Granite Belt	Lettuce	9.2	12.0 g	Capsicum	5.4	8.3 g	Broccoli	2.2	
State average	**Tomato**	**10.7**	**10.0 i**	**Capsicum**	**6.5**	**8.3 g**	**Potato**	**7.2**	**10.0 g**

* includes rockmelons, honeydews, excludes watermelons
c ABS 2004
d various DPI&F Agrilink publications, DPI&F Gross Margin spreadsheets, Water for Profit Fact sheets,, personal communications
f Potato Agrilink; g Water for Profit Fact sheets; h Eric Coleman (pers.comm.); i Des McGrath (pers. comm.); j Capsicum Agrilink; k Jerry Lovatt (pers. comm.); l Lettuce Agrilink; m DPI&F Gross Margins; n Rockmelon Agrilink;

In Queensland, asparagus (0.4 t/ML), broccoli (2.2 t/ML), french beans (2.5 t/ML for machine-harvested North Queensland crops, and 4.0 t/ha for hand-harvested South Queensland crops) and sweet corn (3.1 t/ML) are low order converters of irrigation to crop tonnage. Sweetpotato, potato, melons, capsicum, and eggplant are markedly better (7-9 t/ML). The most agronomically efficient converters of irrigation to crop tonnage of the vegetable crops in Table 13 are pumpkins and watermelons (heavy yields and low, opportunistic irrigation volumes), tomatoes and lettuce (high yields, high precision irrigation applications).

Within a vegetable crop type, there is an understandable trend for superior agronomic WUE in the more temperate growing climates of southern Queensland, where evaporative demand is generally lower, and there is slightly more in-season rainfall.

ECONOMIC WUE

In Table 14, the author has contrasted two methods of determining economic water use efficiency (WUEe) for the major vegetable crops in Queensland. In the left columns, the total industry farm gate value is divided by the total amount of crop irrigation, derived from the project-supplied ABS statistics. The ABS-derived crop yields are also provided as a reference point. In the right-hand columns, the farm gate revenue is developed from DPI&F gross margin sheets for the applicable crop, and this value is divided by the benchmarked irrigation volumes (shown) input to those same gross margin sheets. The values in brackets use best-practice yields or irrigation volumes, rather than general regional values.

For the 12 highest total value crops (tomato to zucchini), there was good agreement between the 2 methods, although ABS over-estimated tomato WUEe by 50%, and lettuce, sweetpotato and pumpkin by 25-30%, and underestimated french bean WUEe by 25%, compared with the DPI&F method. For the five described crops with values less than $15 million (carrot, eggplant, onion, cabbage and celery), the ABS method overestimated WUEe by 50% to150%.

Utilising the DPI&F values, the best WUEe were achieved with tomato, capsicum, and zucchini (depending on irrigation value used), with farm gate revenue of around $9500/ML. The next highest revenues, with WUEe of $6200 to $7200/ML, were lettuce, french beans, sweetpotato, melons and celery. Eggplant was out by itself at $4500/ML, and then a group comprising potato, watermelon, sweet corn, broccoli, onion and cabbage had WUEe of $3000 to $3500/ML. At $1500 to $2000/ML, carrots and pumpkins were the least efficient crops for converting irrigation into farm gate revenue.

When crop gross margin rather than total farm gate revenue is used as the measure of economic performance, the picture changes markedly (Table 15). Sweetpotato becomes a standout performer, delivering $4500/ML of gross margin profit. French bean and tomato yield $3200 to $3700/ML. Melons, lettuce and onions are also solid, producing $1900 to $2200/ML of irrigation.

Although a high revenue earner per megalitre, the high costs of producing capsicum means it only delivers a gross margin WUE of $1200/ML, similar to watermelon ($1600/ML).

There is a significant drop in irrigation investment return with crops like eggplant, potato, pumpkin, celery and cabbage, which yield gross margin efficiencies of $630 to $900/ML. Broccoli and sweet corn returns are even lower ($440–$540/ML), whilst carrots barely break even ($131/ML), and DPI&F gross margins suggest zucchinis are simply unprofitable.

Interestingly, a simple sensitivity analysis demonstrates that dropping vegetable farm gate prices by 20% means 8 (capsicum, sweet corn, broccoli, zucchini, carrot, eggplant, cabbage and celery) of the 17 described crops become unprofitable, thus returning a negative gross margin water use efficiency. This shows the importance of having a profitable and resilient market for product, both in terms of getting a return on increased investment in irrigation improvements, or indeed in switching to supposedly more ‘water-efficient’ crops.

Table 14 – Economic water use efficiency (farm gate $/ML) of crops comprising 90% of Qld production by value (based on ABS statistics)

	Using ABS statistics [c]					DPI&F sourced statistics [d]			
Vegetable crop	Crop value ($M)	Crop area (ha)	Crop yield (t/ha)	Total crop irrigation (ML)	Farm gate return ($/ML)	DPI&F -sourced yields (t/ha)	Nominal farm gate revenue ($/ha)	Nominal irrigation use (ML/ha)	Nominal farm gate return ($/ML)
Tomato	134.7	2 672	37.4	9 351	14 403	40 i	$37 250 m	4.0 g	$9 312 m
Capsicum	59.5	2 043	18.0	5 689	10 450	25 g (32 j)	$22 723 m ($29 320 m)	3.0 g	$7 574 m ($9 773 m)
Potato	46.8	4 761	24.3	16 067	2 911	32 g	$8 632 m	3.0 g	$2 877 m
Lettuce	42.9	1 729	27.8	4 335	9 868	30 l	$18 000 m	2.5 g	$7 200 m
French bean	32.1	3 267	4.6	6 534	4 910	7 g	$14 259 m	2.0 g	$7 130 m
Watermelon	28.9	3 065	20.2	9 820	2 946	40 g	$6 000 m	2.0 g	$3 000 m
Sweetpotato	28.8	980	26.7	3 034	9 478	26.6 h	$24 843 m	3.5 g	$7 098 m
Melons	28.3	1 515	20.5	4 913	5 764	27.0 g	$19 206 m	3.0 g	$6 402 m
Sweet corn	24.0	2 274	11.6	8 035	2 992	11 m (18 g)	$7 689 m ($12 582 g)	3.5 g	$2 197 m ($3 595 m)
Pumpkin	20.6	4 576	11.0	10 089	2 044	20 g	$2 900 m	2.0 g	$1 450 m
Broccoli	17.6	1 471	7.2	4 413	3 993	7.2 o	$12 150 o	3.5 o	$3 471 o
Zucchini	16.9	1 410	8.3	2 115	8 005	20 m (25 g)	$15 250 m ($19 062 g)	3.0 m (2.0 g)	$5 083 m ($9 531 g)
Carrot	14.2	758	31.5	3 033	4 695	32 m	$7 824 m	4.0 m	$1 956 m
Eggplant	12.0	295	36.3	1 180	10 170	35 m	$18 025 m	4.0 m	$4 506 m
Onion	11.9	573	34.1	2 304	5 179	40 m	$11 888 m	4.0 m	$2 972 m
Cabbage	9.1	404	41.9	1 414	6 485	40 o	$12 000 o	4.0 o	$3 000 o
Celery	8.3	223	53.3	891	9 320	60 m	$24 934 m	4.0 m	$6 234 m

* includes rockmelons, honeydews, excludes watermelons
c ABS 2004
d various DPI&F Agrilink publications, DPI&F Gross Margin spreadsheets, Water for Profit Fact sheets, personal communications
f Potato Agrilink; g Water for Profit Fact sheets; h Eric Coleman (pers.comm.); i Des McGrath (pers. comm.); j Capsicum Agrilink;
k Jerry Lovatt (pers. comm.); l Lettuce Agrilink; m DPI&F Gross Margins; n Rockmelon Agrilink; o Brassica Handbooks

Table 15 – Economic return/ML ($gross margin/ML) of crops comprising 90% of Qld production by value (based on ABS statistics)

Vegetable crop	Nominal gross margin m ($/ha)	Nominal gross margin with 20% lower unit price ($/ha)	Nominal irrigation use d (ML/ha)	Nominal GM per ML ($/ML)
Tomato	$9 502	$702	4.0	$3 167
Capsicum	$3 714	–$1 711	3.0	$1 238
Potato	$2 349	$367	3.0	$ 783
Lettuce	$5 378	$1 178	2.5	$2 151
French bean	$7 472	$4 413	2.0	$3 736
Watermelon	$3 134	$1 734	2.0	$1 567
Sweetpotato	$16 066	$10 921	3.5	$4 590
Melons	$6 627	$2 541	3.0	$2 209
Sweet corn	$1 552	–$87	3.5	$ 443
Pumpkin	$1 500	$820	2.0	$750
Broccoli	$1 880	–$640	3.5	$537
Zucchini	–$2 696	–$5 836	3.0	–$899
Carrot	$524	–$1 300	4.0	$131
Eggplant	$3 618	–$477	4.0	$905
Onion	$7 616	$5 079	4.0	$1 904
Cabbage	$2 526	–$274	4.0	$632
Celery	$2 611	–$2 919	4.0	$653

d various DPI&F Agrilink publications, DPI&F Gross Margin spreadsheets, Water for Profit Fact sheets, personal communications

m DPI&F Gross Margins

VEGETABLE IRRIGATION SYSTEMS AND PRODUCT QUALITY

The following section outlines

- vegetable crops, selected from the main vegetable crops grown in Queensland
- principal irrigation systems used, and
- general comments on how production and crop quality is affected by variations in water supply quantity and quality.

Generally, although producers will try and maintain production with the water supplies they have at hand, they will generally invest in more efficient irrigation infrastructure or practices, try and develop other water sources, or shift production, rather than under-irrigate their crops. Experience has shown that vegetable yields and particularly product quality can rapidly decline if insufficient water is supplied to meet minimum crop water requirements.

Tomato

Almost exclusively drip and polyethylene mulch, predominantly trellis production

Reduced production from Bowen and Granite Belt in seasons of low water supply, some shifting of production areas within Lockyer and Wide Bay when locales have reduced water availability. Occasional issues with calcium-related disorders (e.g. blossom end rot) when growers cannot keep sufficient water up to plants during hot, dry conditions.

Capsicum

Predominantly drip and polyethylene mulch

Reduced production from Bowen and Granite Belt in seasons of low water supply, some shifting of production areas (e.g. Bowen to Burdekin) or within Lockyer and Wide Bay when locales have reduced water availability.

Potato

Mix of travelling gun, travelling boom, solid set sprinklers and hand-shift sprinklers throughout Qld. Some drip systems (particularly Wide Bay, Lockyer and Darling Downs)

Reduced production in areas subject to water shortages. Internal tuber disorders (e.g. hollow heart and brown fleck exacerbated by sporadic or uneven irrigation and high night temperatures). Reduced tuber initiation and bulking in under-irrigated hand shift systems.

Lettuce

Previously predominantly solid-set sprinklers; significant shift to drip in southern Qld with onset of current water shortages

Producers focus on maintaining quality of reduced planting areas when water in short supply – occasional problems with uneven maturity and internal disorders (e.g. tip burn) when limited water supply exacerbates adverse effects of hot dry weather during heading.

French bean

Previously predominantly hand-shift sprinklers, solid-set sprinklers, or travelling gun irrigators. Major shift to drip irrigation in Bowen 10-15 years ago. More recently shift to travelling boom irrigators (Lockyer, Wide Bay, South Coast), more drip irrigation (in Lockyer and Wide Bay), some centre pivots and other high precision overhead systems in Burdekin.

Major moves to drip irrigation to maintain bean yields and quality in areas where water supply and quality declines. Beans very sensitive to overhead applications of saline irrigation water. More uniform irrigation also reduces issues with uneven maturity and wet field locations at harvest.

Watermelon

Full suite of irrigation systems, from hand-shift sprinklers through to drip and polythene mulch

Level of irrigation sophistication depends on whether producer is broadacre grower opportunistically cropping, through to specialist high-value seedless melon grower. Main responses when water is scarce are not to grow, to reduce production area, or to accept lower yields with less irrigation (particular opportunistic cropping). Specialist producers more akin to rockmelon production systems, with focus on irrigating for high quality.

Sweetpotato

Mix of solid-set, travelling gun, travelling boom and drip irrigation. Move to travelling boom and drip irrigation in Wide Bay and Central regions.

Recent research demonstrating higher yields, with more evenly sized and shaped roots in response to more precise irrigation and reduction in water stress at establishment. Irrigation seen to play an increasingly critical role in maintaining profitable production through high yields of consistently sized, marketable storage roots. Precision, low volume irrigation systems assist reduction of water stress at planting and storage root initiation in times of water shortages, or reliance on poorer water quality. Cooling effect of overhead irrigation may be important when establishing cuttings in hot dry conditions.

Melons

Predominantly drip and polyethylene mulch

Reduced production from Bowen and Darling Downs in seasons of low water supply, some shifting of production areas (e.g. Bowen to Burdekin) or within Darling Downs and Wide Bay when locales have reduced water availability. Significant research and development investment recently in identifying irrigation impacts and best practices for maximising sugar and flavour levels in late season irrigation. Good plant water status until harvest required to maximise melon eating quality (previous strategy of 'drying-off' prior to harvest shown to be erroneous). Melon industry focussed on quality assured practices to deliver consistently high eating melons.

Sweet corn

Many producers using travelling guns, travelling booms, but all of Bowen is under drip, significant drip in Lockyer, and there is increasing use of centre pivots in Burdekin, and potentially in Wide Bay.

Reduced production from Bowen, and some shifts to Burdekin in seasons of low water supply, some shifting of production areas within Lockyer and Wide Bay when locales have reduced water availability. Change to drip systems in Lockyer when water is scarce. Producers intuitively concentrate irrigation during pollination and kernel fill to maintain cob quality at the sacrifice of overall yields. Because industry dominated by a few major producers with significant national contract arrangements with supermarkets, industry is very proactive in dealing with water shortages. Responses include moving to new districts, implementing new technology, and purchasing water from other users.

Pumpkin

Full suite of irrigation systems, from hand-shift sprinklers through to drip and polythene mulch

Similar to watermelon, level of irrigation sophistication depends on whether producer is broadacre grower opportunistically cropping through to specialist grower. Main responses when water is scarce are not to grow, to reduce production area, or to accept lower yields with less irrigation (particular opportunistic cropping). Specialist producers more akin to rockmelon production systems, with focus on irrigating for consistent quality.

Broccoli

Full suite of irrigation systems; Including instances of hand-shift sprinklers, furrow irrigation on Darling Downs, and travelling guns. Predominantly solid-set sprinklers, travelling booms, and drip systems.

Reduced production and shifting of locales in Granite Belt, Lockyer and Wide Bay in times of water shortage. Several major producers change bed configurations and use drip systems when water becomes scarce or reduced in quality. Situation is similar to lettuce and sweet corn, where major producers are very proactive when water becomes scarce, sourcing new growing locations, buying water, or adapting production systems. Producers very conscious that poor irrigation creates uneven heads and maturity, increasing harvesting and grading costs and reducing prices.

Zucchini

Some solid-set sprinklers, major use of drip and plasti-culture

Smaller producers will reduce or cease production when water unavailable. Major producers in Wide Bay, South Coast and Granite Belt will shift location or attempt to access other water (e.g. potable supplies, recycled schemes) to maintain production.

Carrot

Mix of travelling guns and booms, and solid-set sprinklers; a few centre pivots

Industry becoming more concentrated into a few major, relatively sophisticated producers/packer/minimal processors. These producers are very proactive when water becomes scarce, particularly sourcing new growing locations. Producers try and maintain quality through sufficient irrigation and reduce production areas accordingly. Many have significant investment in packing infrastructure, so are very driven to maintain production levels.

Eggplant

Some solid-set sprinklers, major use of drip and plasti-culture

Major producers in Wide Bay, will shift location or attempt to access other water (e.g. potable supplies, recycled schemes) to maintain production. Bowen producers will shift locales, or reduce production – some shift of Northern industry to Burdekin.

Onion

Mostly solid-set sprinklers, some investment in travelling booms, and use of drip irrigation when water very scarce.

Major producers in southern Queensland will source locales with better water supplies during water scarcity. Significant trialling by producers of drip irrigation and supplementary irrigation strategies to try and maximise yields and returns per ML. Similar to other industries, major packing sheds try to maintain throughput, and ongoing negotiations with client packers and supermarkets to proactively renegotiate supply and onion size arrangements to cope with water shortages. Smaller producers reduce planted areas.

Cabbage

Full suite of irrigation systems; Including instances of hand-shift sprinklers, and travelling guns. Predominantly solid-set sprinklers, travelling booms, and some drip systems.

Similar to broccoli; reduced production and shifting of locales in Granite Belt, Lockyer and Wide Bay in times of water shortage. Several major producers change bed configurations and use drip systems when water becomes scarce or reduced in quality. Situation is similar to lettuce and sweet corn, where major producers are very proactive when water becomes scarce, sourcing new growing locations, buying water, or adapting production systems. Producers very conscious that poor irrigation creates uneven heads and maturity, increasing harvesting and grading costs and reducing prices.

Celery

Solid-set sprinklers and drip systems

This industry is dominated by a very few major producers. To preserve contracts and markets, in times of declining water resources, they preserve irrigation for celery by diverting it away from other crops on farm, and access other water through leasing land or buying water in rare circumstances. They also readily invest in and use drip irrigation to eke out production from declining water resources.

SALINITY IN VEGETABLE GROWING REGIONS

Compared to many areas in Australia, Queensland is currently fairly well off with respect to the occurrence of irrigation-induced salinity, and even dryland salinity. That is not to say that the hazard does not exist, rather that the geomorphology of many of our older irrigation areas means they are less prone to salinisation, and, in the higher risk areas, the period of irrigation is significantly less than in southern Australia.

The two main salinity issues in the coastal irrigation areas are seawater intrusion from excessive pumping of groundwater. The other is ‘forced’ utilisation of more saline groundwater sources as the fresher groundwater is depleted by irrigation, particularly following consecutive seasons of low rainfall and consequent low recharge. The Queensland Department of Natural Resources and Mines has identified these risks in its water resource allocation strategies, and implemented policies and management regulations to minimise saltwater intrusion from either the sea or proximate saline aquifers into freshwater resources.

Table 17 present a regional overview of salinity levels in some representative surface and groundwater sources used for vegetable irrigation. This information is gleaned from a wide range of specific regional studies, general NRM station logging, and irrigation provider statistics.

Table 17 – Salinity issues in Queensland vegetable production regions

Region	Water quality issues
Far North	Surface water good*, e.g. Mareeba mean salinity 112 µS/cm
	Groundwater good, 91% of bores EC < 1700 µS/cm
	Some watertable salinity adjacent to irrigation channels, program of channel lining implemented.
Burdekin	Generally moderate to good water quality (river and groundwater; high turbidity in river water, areas of moderate quality groundwater and risks/actual irrigation salinity through rising groundwater). Implementation of water allocations, extraction and irrigation plans to reduce risk of sea water intrusion into aquifer.
	Surface quality good* along Haughton and Burdekin Rivers (e.g. 200 µS/cm), only moderate** on Bararatta Creek (e.g. 290 µS/cm).
	Groundwater variable; 45% of bores < 1700 µS/cm, 26% 1701 to 4300 µS/cm, 29% > 4300 µS/cm.
Bowen–Mackay	Bowen (principal vegetable growing district)
	Significant risk of salt water intrusion from coastal seawater and poor quality underlying aquifers further inland, if groundwater over-used; groundwaters currently highly variable, with significant areas at 2500-5000 µS/cm (Gilbey 2004).
Central	Surface water salinity in the Fitzroy basin is generally good to moderate, e.g. 150 µS/cm in the lower Fitzroy River, 250 to 300 µS/cm in Nogoa–Mackenzie storages (DNR&M 2005). Groundwater is highly variable; vegetable cropping in the Lower Fitzroy often uses irrigation water 1700 to 2400 µS/cm (Coleman 2005). There are sporadic areas of dryland salinity in upper and lower Fitzroy and tributaries.

Region	Water quality issues
Wide Bay	Frequent occurrence of patchy dryland salinity throughout Burnett basin in susceptible landscapes. Overall water quality moderate. Implementation of water allocations, extraction and irrigation plans to reduce risk of sea water intrusion into aquifer. Surface quality good* along Kolan River (e.g. 450 µS/cm), only moderate** on Burnett River (e.g. 700 µS/cm). Groundwater generally good in Kolan–Burnett; 83% of bores < 1700 µS/cm, 8% 1701 to 4300 µS/cm, 9% > 4300 µS/cm. Over 65% recently accessed groundwater in the lower Mary River valley has EC > 4300 µS/cm.
Upper Burnett	Frequent occurrence of patchy dryland salinity throughout Burnett basin in susceptible landscapes, associated with dryland cropping (Landscape Resource Assessment and Management 2004). Surface water salinity generally low to moderate (e.g. Jones Weir 701 µS/cm, Three Moon Ck 937 µS/cm), except if adjacent to dryland salinity outbreaks. Some evidence of salinisation of groundwater where excessive drawdown of localised freshwater aquifers occurs.
South Coast	Low levels of salinity in surface waters in the upper Mary River water storages (e.g. 280 µS/cm at Borumba Dam), but poorer water quality in western tributaries (e.g. 1300 µS/cm). Surface water salinity in the non-estuarine reaches of streams draining the coastal areas north of Brisbane were generally good (e.g. North Pine 350 µS/cm, Maroochy River 264 µS/cm), whilst the rivers south of Brisbane may be slightly more saline, but still good (e.g. Logan River 630 µS/cm) Although there is localised use of groundwater, there have been few studies of groundwater quality or trends in most of this region (NRMSEQ 2004). Generally, where groundwater is used, it is of good quality, although frequently low volumes. Anecdotal and preliminary NRM evidence suggests saltwater intrusion is a problem in coastal areas where groundwaters are over-exploited. Many alluvial systems are recharged by surface water flows or releases, with quality improvement at the same time. With urban encroachment, many of these resources may have limited future use in agriculture in any respect. There is some use of high cost, reticulated water for intensive vegetable growing in peri-urban areas; this is obviously of potable quality.
Lockyer–Fassifern	Isolated pockets of dryland salinity. Creek water generally moderate quality when flowing; aquifer water variable; increased reliance on more saline water sources as general aquifer levels drop. Surface water in the major irrigation storages (when they contain water) is generally good quality (e.g. Moogerah Dam 304 µS/cm, Atkinson Dam 206 µS/cm, Bill Gunn Dam 187 µS/cm). Stream salinities are variable, with Lockyer, Laidley, Tent Hill, Murphy's and Buaraba Creeks <1000 µS/cm. Other major tributaries (Flagstone, Ma Ma and Tenthill Creeks) have moderate salinity levels of 1300-2900 µS/cm. Other creeks such as Sandy, Plain and Woolshed Creeks are higher (>8000 µS/cm). The situation is similar in the Bremer and Fassifern Valleys; for example headwater streams such as Reynolds and Warrill Creeks and upper Bremer are 650-1300 µS/cm, whilst Purga and Bundamba Creeks are 2900-5200 µS/cm (SEQWCG 2004). Groundwater salinity 0-2000 µS/cm in Upper Tenthill Creek, Laidley Creek, and Lower Lockyer, but ranging from 2000 µS/cm up to 14 000 µS/cm in pockets of alluvium along upper Lockyer Creek, Flagstone Creek, Ma Ma Creek, Sandy Creek and mid-Laidley Creek. In some areas there is a strong correlation between decline in groundwater levels and increasing salinity (Department of Natural Resources and Mines 2003).
Darling Downs	Localised dryland salinity, some rising stream salinities. Most vegetable production in better water quality areas (Department of Natural Resources and Mines 2005). Generally, surface water direct from streams or from harvesting of overland flows is good quality (e.g. 20th to 80th percentile values for Condamine-Balonne catchment 312-570 µS/cm) (Wilson and Adams 2004). Salinity levels in extracted groundwater vary depending on source (e.g. Queensland Basalts versus Great Artesian basin (Ife and Skelt 2004); indicative levels are 1000-4500 µS/cm, average 1700 µS/cm. Salinity may increase with intrusion of more saline waters into over-extracted systems.

Region	Water quality issues
Granite Belt	Generally good quality stored run-off water on farm, or pumped from creeks (e.g. 130 µS/cm in Quart Pot Creek, 307 µS/cm in Broadwater Creek. Some use of moderate salinity irrigation water in Stanthorpe recycled water scheme. Generally sandy soils so short-term management relatively straightforward. Very limited and localised use of groundwater in vegetable growing areas; no data available on salinity levels or trends.

*good surface water - <20% of sample sites have EC > 250 µS/cm (350-570 µS/cm in SE Qld)
**moderate surface water – 20-50% of sample sites have EC > 250 µS/cm (350-570 µS/cm in SE Qld)
***poor surface water - >50% of sample sites have EC > 250 µS/cm (350-570 µS/cm in SE Qld)From (Department of Natural Resources and Mines 2005; DNR&M 2005; Hunter, Witting et al. 2003)

VEGETABLE IRRIGATION BENCHMARKING

Using information collected from participating grower surveys, on-farm trials, and DPI&F experimental work, the Water for Profit program published a series of worksheets (Water for Profit 2005) that give benchmark water use and irrigation requirements for common Queensland vegetable (and fruit) crops (Table 18). Many of these are regionally specific. The values in Table 18 reflect the least irrigation required to achieve maximum yields in either the graphical data set or the accompanying text provided in the benchmarking information sheets. Most benchmarking data assumes the optimised use of solid-set sprinkler irrigation or centre pivots (beetroot, brassicas, lettuce, beans, onions, potatoes, pumpkins, potatoes, sweet corn, sweetpotato) or drip irrigation (capsicum, melons, tomatoes, cucurbits).

It would be interesting to review these benchmarks in the light of the uptake of precision irrigation systems such as drip, and the intensity of irrigation management, that has accompanied water scarcity in many regions. It is likely that with innovation, economic pressures, and water limitations, these benchmark values have fallen by a significant percentage in some crops. In a recent case study with drip-irrigated lettuce, the grower suggested only 1.3 ML/ha of irrigation was required per winter crop, in addition to 30 to 40 mm of rain. This compares with his previous benchmark figure of 2.3 ML/ha.

Table 18 – Benchmark irrigation requirements for selected vegetable crops from Water for Profit Information Sheets – June 2005

Vegetable crop	Best management benchmark irrigation
Beetroot	2.2–3 ML/ha
Broccoli	2.5–3 ML/ha
Cauliflower	3–3.5 ML/ha
Capsicum	2–3 ML/ha
Green beans	1.8–2.5 ML/ha
Lettuce	2.2–3 ML/ha
Onion	2–5 ML/ha, (highly variable, depending on region and growing period)
Potato	3–5 ML/ha, (highly variable, depending on region and growing period)
Pumpkins	1.5–2.5 ML/ha
Rockmelons and honeydews	2–3 ML/ha
Sweet corn	3.4–4 ML/ha
Sweetpotato	3 ML/ha
Tomato	4 ML/ha
Tomato (NQ)	2.5–3.5 ML/ha
Zucchini and squash	1–2 ML/ha

IRRIGATION SCHEDULING AND ADOPTION OF HIGH TECHNOLOGY

In considering irrigation scheduling currently used in Queensland vegetable production, the main technologies are broadly categorised into four categories: intuition; weather-based; simple soil-based; and complex systems.

Intuition or gut feel

This usually comprises irrigating to a set pattern, intuitively accounting for evaporative demand, rainfall, crop growth stage, and water availability and quality. There is some feedback by monitoring crop performance, and a 'kick the dirt' approach to soil moisture assessment. The use of this style of irrigation scheduling can come about because:

- Water management is not a high priority for the producer, compared with other competing issues such as pest issues, product marketing, and labour management.
- The producer does not believe an objective measurement system would give better water use efficiency or crop performance, or alternately believes efficiency or production gains would be too small to justify the cost and time investment.

- The producer has previously used irrigation scheduling equipment, and had a bad experience, e.g. equipment failure, poor crop performance, too complex or costly for the results achieved.
- The producer has previously used irrigation scheduling equipment, and believes that they have gained enough instinctual knowledge and experience to be able to replicate the results without ongoing investment in objective measures.

Weather-based and water budget systems

There is currently very little stand-alone use of water budget type approaches in vegetable irrigation, other than relatively simple recording of rainfall and irrigation quantities, and comparing these with intuitive or historical guestimates of crop water requirements.

Simple tools, e.g. tensiometers, hand-held manual moisture probes

These relatively simple, unautomated tools are used in most vegetable crops and growing regions across Queensland, but tend to be found in concentrated pockets and crop types. This is usually associated with a specific extension campaign by either government extension officers (e.g. in Bundaberg tomatoes during the early 1990s, Lockyer lettuce and potatoes during the mid 1990s), or local resellers with an experienced sales and service person who can provide effective advice on their use.

Research has clearly shown that simple equipment such as tensiometers can optimise water use efficiency in most vegetable production systems (Henderson 2003). Original models with inbuilt pressure gauges were somewhat high maintenance to ensure continuously reliable readings, and in recent times became relatively expensive at $250 per unit. The availability of septum type systems with cheap tensiometer tubes ($30) and a loggable electronic reader ($800) capable of repeatable measurement at each tube has markedly increased the utility of tensiometer-based scheduling systems. (Henderson 2003) estimated the full cost of a tensiometer-based scheduling system for crops such as lettuce, brassicas, at around $100/ha (including all equipment, labour, and data management requirements). In recent years we have seen an increased uptake by growers in certain regions, particularly the Lockyer Valley, South Coast, and Bowen areas.

Electronic irrigation scheduling systems

Electronic scheduling systems cover the full range of capacitance, heat dissipation, and matrix block sensors, with either manual or electronic logging, data storage and distribution. Often they have associated software and irrigation management programs. Some systems even fully automate irrigation management by linking to irrigation controllers.

In Queensland vegetable growing, there has been significant interest in these electronic systems associated with:

- Extension and operation by consultancy firms, e.g. Crop Tech PL in the Bundaberg district. The level of service provided can vary from supply of the scheduling equipment through to a full irrigation consultancy service, involving the consultant in taking the soil moisture readings, and making ongoing irrigation recommendations.
- Extension, sales and technical support by equipment suppliers and retailers – as equipment suppliers see a business opportunity they promote types and levels of equipment, and levels of after-sales service and backup to interested producers as a commercial service.

- Extension and demonstration by government and NRM programs, such as the Water for Profit program under the Queensland Government funded Rural Water Use Efficiency Initiative (Clark 2003), provide demonstration units and support backup for a short period to allow the grower to asses the cost–benefit in ongoing investment in such systems.

A general assessment of the use of these electronic systems in Queensland vegetable production suggests a variety of outcomes:

- Ongoing use by highly capitalised businesses, with automated irrigation systems, and in-house agronomic and electronic specialists to maintain service.
- Ongoing use by businesses with a successful relationship with a reliable consultant who is familiar with the integration of these systems in whole farm operations.
- Ongoing but lower level use by large scale businesses that purchased some equipment but not enough to cover their suite and areal extent of normal operations. These businesses often have access to an agronomist (either in-house or external), and use the irrigation scheduling equipment to investigate new production systems, new sites, or any other agronomic change they implement. Once they are confident they have their irrigation relatively well sorted, they switch to a calibrated, simpler system (e.g. tensiometer or matrix block-based), or rely on experience and intuition with the new production strategy. This type of use is more common than the former two practices.
- Use of demonstration or leased equipment to evaluate their irrigation practices (such as under the auspices of a RWUE-type program), to make adjustments and to re-evaluate, but no actual investment in private purchase or ongoing lease of the equipment. This is also a relatively common scenario.
- Initial use of the electronic systems, but cessation after a short-medium term. Commonly this occurs because of equipment failure and no redress because of lack of support from supplier (either through initial supplier no longer in business, or producer unable to fund ongoing support); or lack of follow-up support by extension agent (private or public) and consequent producer frustration. This is currently also an unfortunately common scenario in the Queensland vegetable industry.

IRRIGATION INFRASTRUCTURE CHANGES

In the last decade there has been significant investment in changing and improving irrigation system infrastructure in the Queensland vegetable industry. A major component of the RWUE program has been system evaluation and recommendations for improvement or change. Examples are changing pump configurations and performance to improve energy efficiency to more closely match system requirements. This has been particularly common where producers have moved from high pressure systems such as hand shift sprinklers or travelling guns to low pressure booms or drip tape.

Another common response to an adverse evaluation is reconfiguration of sprinkler systems following assessment of low distribution uniformities from current designs and equipment. The responses included reduced lateral spacing in solid-set sprinkler designs to improve overlap, changing sprinklers to more wind resistant heads, or changing sprinkler or boom nozzles to match irrigation output with soil infiltration rates.

As the droughts have hit regions hard, there has been a huge increase in utilisation of drip systems for vegetable production. In many solanaceous and cucurbit crops, this had already been common since the late 1980s, but recently the use of drip tape has expanded to crops such as potato, sweetpotato, lettuce, brassicas, beans and sweet corn. The move to drip tape is often accompanied by an increase in using automated irrigation controllers.

RESEARCH ON IRRIGATION SYSTEM CHANGES

In his research program studying the costs and benefits of changing irrigation systems and practices, (Henderson 2003) found that, on average, conventional drip irrigation yielded 15% more marketable produce than sprinkler-based strategies, and used 10% less water, improving agronomic water use efficiency (tonnes of produce per megalitre of irrigation) by about 25%.

Using economic models, he calculated the potential economic value to Queensland vegetable producers of adopting drip irrigation, in circumstances where the availability of irrigation water was the factor limiting production. (The current drought is one such scenario.) In his analyses, he modelled 30% of Queensland onion, potato, lettuce, sweet corn and sweetpotato producers switching to drip irrigation from sprinkler-based strategies, and produce prices marginally higher than long-term averages (assuming produce shortages increase prices). In such a scenario, conventional drip irrigation increased profit (not revenue) to producers by $2.2 million per annum, whilst using the water-efficient deficit drip system increased profit by an additional $1.3 million per annum more than conventional drip irrigation.

This research project clearly demonstrated that the economic viability of changing to a new irrigation strategy depended on its relative agronomic water use efficiency and its cost of implementation, and was very sensitive to produce price and the factors that are constraining production.

For example, at a standard district onion price of $485/t at market, the research showed:

- A sprinkler-irrigated system gave the best profitability when the amount of produce required was the restricting influence, that is, when the market will not take any more produce.
- A conventional drip system was most profitable if the amount of land available was the constraining factor.
- A deficit drip irrigation system was most profitable if the amount of water available was limiting production.

As a rule of thumb, irrigation systems and strategies that deliver superior agronomic water use efficiency, but are more expensive than current systems, are favoured by higher produce prices, restricted irrigation water supplies, and good opportunities for market expansion. Conversely, low produce prices, readily available irrigation water supplies, and restricted markets for produce favour less investment in irrigation management, even at the expense of reduced water use efficiency.

This is precisely why there were wholesale changes to drip systems in the Bowen district about 12 years ago when water became very restricted, and why there have been massive increases in the use of drip in south-east Queensland in the last 4 years. As one method of improving water use efficiency, conventional drip systems can be adapted for most vegetable production systems to produce high yields of quality produce. Adoption is probably influenced more by the economic and water policy environments than any major agronomic issues.

IRRIGATION SYSTEM TRENDS BY REGION

Far North

Limited use of tensiometer-based systems for some crops, particularly potatoes. Under previous and current consultant-based programs, good support for electronic systems on the Atherton Tableland. Supported by RWUE program with on-farm workshops and demonstrations, and Financial Incentive Scheme (FIS) packages to install irrigation scheduling equipment (69 approved applications as at May 2003). Probable that irrigation scheduling will be increasingly emphasised for coastal vegetable regions draining into the Great Barrier Reef Lagoon as part of a nutrient mitigation farm management system.

Predominant irrigation systems are solid-set, followed by travelling guns, with some increasing use of low pressure overhead irrigators and drip tape. During the period of financial incentives under the RWUE program, 52 producers received funding for improving distribution uniformity of current systems through reducing lateral spacing or changing sprinkler fittings.

Burdekin and Bowen–Mackay

The RWUE program noted 175 assistance approvals for irrigation scheduling equipment, including tensiometers, and manual or automatic logging capacitance probe scheduling systems. There were also 103 successful applications for system improvements, including replacing sprinklers in overhead systems, improving filtration systems and automating irrigation controllers.

The Burdekin area has seen investment in both drip systems for solanaceous and cucurbit crops, and extensive investment by some larger producers in centre pivot systems for vegetables, particularly sweet corn.

In Bowen, there was a major shift to drip irrigation back in the 1990s, with more recent finetuning investment in electronic scheduling, and automated fertigation and irrigation controllers.

Central

Soil moisture monitoring was highlighted in best management practice workshops held under the auspices of the RWUE program, with 38 successful applications for financial assistance to horticultural growers to purchase tensiometers or capacitance-based scheduling devices. Around 50 successful assistance applications for system improvements included expansion or networking of existing dam sources, improvement of fertigation systems, or conversion to drip systems. With ongoing drought conditions, there has been considerable effort in systems and practices to utilise increasingly saline water sources.

Burnett

This major vegetable growing area has a history of innovation adoption, with significant adoption of irrigation scheduling using tensiometers, (formerly) neutron probes and (currently) electronic capacitance probe devices. This has been strongly serviced by various consultancy groups, notably Crop Tech PL in recent years, providing a range of service levels from equipment supply, through to full irrigation and nutrient monitoring and management.

There have also been significant efforts in system improvement and equipment upgrading promoted by local irrigation retailers, and product wholesalers such as drip tape manufacturers. Many vegetable industries (solanaceous, cucurbits) already widely use drip tape and scheduling systems. Recent water shortages have seen other crops such as potato and recently sweetpotato also utilising drip irrigation, switching from travelling guns or hand-shift sprinklers. Solid-set sprinklers are often still retained for crop establishment.

The RWUE program recorded 114 successful applications for systems improvement grants and 78 successful irrigation scheduling grants between 2000 and 2003.

South Coast

During the RWUE program, there was significant interest in irrigation scheduling equipment, with 70 successful financial assistance applications. As in other regions, this was generally for simple tensiometers or logging capacitance probes. Many vegetable farms are relatively small in comparison with other growing areas, but some case studies showed 15% to 60% savings in water use, or production improvements of 20%, from irrigation scheduling.

Apart from system maintenance or the addition of automated controllers or fertigation capacity, there has been some increased adoption of drip irrigation in the South Coast. Apart from saving water during drought, there has also been some appeal from reduced ongoing labour requirements, as many small crop vegetable farms had previously relied on hand-shift sprinklers as their principal irrigation systems. According to RWUE figures, there were 150 successful financial assistance applications for system improvement during the period of the FIS operation.

Lockyer–Fassifern, Darling Downs, Granite Belt

The recurrent droughts in the past decade have hit southern Queensland vegetable producers particularly hard. The ongoing crisis has seen significant investment in practice change, irrigation system improvement, and major shifts in the physical and social farmscape as vegetable growers seek to cope with scarce water supplies. Through the RWUE program, there has been extensive demonstration of irrigation scheduling using either tensiometers (range of types), and/or logging probes, including capacitance gear, and more recently matrix block sensors. Local irrigation suppliers routinely now sell a range of tensiometer types as stock items. The RWUE program recorded 134 successful applications for financial assistance to purchase and install new irrigation scheduling equipment between 2000 and 2003.

The last few years have seen a major evaluation and installation of drip irrigation in the Lockyer and Granite Belt regions. These system changes have been supported by trials and demonstrations by drip suppliers, the Water for Profit program, and the DPI. Many producers would simply not have been able to produce viable areas of vegetable crops without switching to drip irrigation in the past 2 years. Many of these growers have retained their solid-set systems to assist with crop establishment or to provide cooling irrigations in pre-harvest periods.

Vegetable growers have also made considerable investment in upgrading their current overhead systems. For example, several producers have purchased new sprinkler types to try and improve the distribution uniformities of their solid-set systems. Others have replaced nozzles on their travelling irrigators, or even centre pivots on the Darling Downs, to try and better match irrigation rates with soil infiltration rates. The RWUE program recorded 249 successful applications for system improvement during the FIS operating period. There has probably been as much if not more investment in improving irrigation systems in the years since, as the water shortages have become even more severe.

ACCESS TO VEGETABLE INDUSTRY INFORMATION

Rural Water Use Efficiency initiative

The Queensland vegetable industries participated in the Queensland Government funded Rural Water Use Efficiency improvement programs that commenced in 1999, and have continued in various guises until the present day. The program targets provision of information and irrigation improvement services, with on-ground field staff employed under the Water for Profit banner, a section of Growcom PL (formerly Queensland Fruit and Vegetable Growers).

The program includes a broad range of extension services, including one-on-one advice to producers, organised field days and training courses, a dedicated website (http://www.nrm.qld.gov.au/rwue/), and a resource CD that includes a wide range of generated and sourced horticultural irrigation information. There are also awareness and technical articles in industry journals, such as Fruit and Vegetable News, and Good Fruit and Vegetables.

The best summary of this service was the 2003 RWUE milestone report (Clark 2003). It concludes that, by 2003, 90% of horticultural growers were aware of the extension service, with 45% of horticulture growers implementing system improvements or changing irrigation practices.

In a separate review of the RWUE program (Coutts and Bell 2003) stated that 70% of horticultural industry respondents reported participation in the RWUE initiative, with 53% rating the knowledge gained as moderate or better. About 70% of horticultural growers indicated they had or would make changes to their irrigation practices as a result of involvement with the program, whilst the numbers suggest that around 41% of Queensland horticultural irrigators were successful applicants to the RWUE Financial Incentive Scheme. The RWUE reviewers found 'This combination of awareness and participation is an incredible achievement in any circumstances'. This review provided a comprehensive analysis of the benefits to vegetable industries and the wider community from the RWUE training and extension program.

Department of Primary Industries (Queensland)

The Department of Primary Industries (Queensland) provides several resources of irrigation information to vegetable producers. These include, but are not limited to:

- The series of Agrilink and Crop Management handbooks with detailed sections on irrigation management included in the total package of farming information. Vegetable crops covered in detail include lettuce, rockmelon and honeydew, sweetpotato, tomato, brassicas. (Onion, potato, capsicum and chilli Agrilink publications have been published but are currently out of print.)
- DPI&F Notes, available via the website (www.dpi.qld.gov.au).

CRC Irrigation Futures

In 2003, the Cooperative Research Centre for Irrigation Futures (www.irrigationfutures.org.au) was formed as an entity to encourage a national approach to irrigation research, education and training. Through its member institutions, it provides a range of formal tertiary education course, industry workshops and forums, research programs, and training packages, many of which are appropriate for vegetable producers.

Irrigation Association of Australia

Apart from training and networking opportunities for irrigation industry service professionals, one of the main contributions of the IAA is its annual national conference. The IAA conference showcases the latest developments in irrigation technology and practice, provides forums for vegetable producers and industry professionals to interact, and showcases the latest equipment from irrigation industry suppliers. Many large vegetable producers have attended these conferences in the past, or alternatively funded participation by their key irrigation staff. The IAA also produces a range of irrigation publications, particularly associated with equipment performance and evaluation, maintenance and improvement.

Consultancy services

The large vegetable growing areas are serviced by private consultancies, and there are certainly significant consultant services targeting vegetable production on the Atherton Tableland, Bowen, Burnett, South Coast, Lockyer, Eastern Darling Downs and Granite Belt. These consultants span individuals with a few key clients through to regional businesses, and some businesses with formal links to national alliances with significant Australia-wide presence. The consultants offer advisory and research services, ranging from one-off inquiries to irrigation system and infrastructure evaluation through to regular and intense irrigation monitoring and management. In recent years, many of these consultants have not been as active in irrigation management as in the past. This may be because, as growers become larger, they may often employ their own irrigation managers, with access to much of the automated logging and controller equipment previously the bailiwick of the consultancy firms.

Agribusiness providers

Most of the Queensland vegetable growing regions have several irrigation equipment and service supply companies. Apart from advice on equipment selection, maintenance and operation, many of them also provide general advice on issues such as using tensiometers for irrigation scheduling. These well-established companies are an important traditional source of general information to vegetable producers in the major vegetable growing regions.

In recent years, many wholesale equipment suppliers, and particularly the drip equipment manufacturers, have their own network of technical and sales staff that interact directly with vegetable producers. This extends not just to equipment advice, but to actual demonstration trials, field days, and extension materials. In addition, several companies offer intensive individual support to larger growers using their products for the first time. This intensive, one-to-one service has been an important factor where we have seen large scale changes in irrigation systems such as the conversion of sprinkler systems to drip in the Lockyer and Granite Belt regions in the past few years.

Irrigation training for vegetable growers

A major training and extension program for production horticultural growers (including vegetable producers) since 1999 has been the Queensland Government funded Rural Water Use Efficiency program. Since 2004, Stage 2 of the adoption and training program is being delivered by Growcom PL under the Water for Profit badge. During Stage 1 of the Horticulture RWUEI, the Water for Profit program was led by Queensland Fruit and Vegetable Growers (now Growcom PL), and involved staff from DPI&F and National Centre for Engineering in Agriculture. Stage 1 has been reviewed and extensively reported on (Clark 2003).

From the Executive Summary of the Final Milestone Report on that program:

As at June 2003, during the four-year program, Water for Profit:

- Has a high level of recognition in the horticultural industries, with over 90% of growers aware of the program and the drive to increase irrigation efficiency.
- Has had almost 45% of horticultural growers participating in changed irrigation management practice and improvements.
- Has had over 6000 attendances at activities and workshops, aimed at assisting growers improve irrigation efficiency.
- Has had almost 1500 individual growers participate in BMP activities.
- Has assisted over 1400 growers through the Rural Water Use Efficiency, Financial Incentive Scheme.
- Has generated more than $162 million of gains in water savings and productivity.
- Significantly, has returned $23 in efficiency gains for every $1 invested in the program by the state government.
- Was announced as the winner of the FarmBis Training and Education Category of the Queensland Primary Industry Week Awards in April 2003.
- Has produced over eighty information sheets to assist growers improve irrigation efficiency.

The program delivered training through visits to individual farm sites, industry workshops and field days, and information sheets on the web (http://www.nrm.qld.gov.au/rwue/factsheets.html; http://www.growcom.com.au/WaterForProfit_fs.html), through a self-contained fact sheets CD (Water for Profit 2005), written media, including Fruit and Vegetable News, local, regional and state newspapers, Irrigation Association of Australia National Conferences, radio and television awareness appearances.

The program also encouraged participation through a financial incentives scheme to assist producers participate in system infrastructure improvement, adopting irrigation scheduling methods, or individual consultancy or training. Across Queensland horticultural producers, there were 2073 applications for incentive packages, with approvals consisting of 29 for training, 799 for system improvement, 607 for irrigation scheduling equipment and application, and 59 for water meters (total 1494).

Stage 2 of the Water for Profit industry training program is continuing at a reduced level of investment and activity. It is still providing training workshops for issues such as salinity and nutrient management, and on-farm assistance with system evaluation and improvement, and implementation of irrigation scheduling (Wallace, pers. comm.)

Apart from the Water for Profit program, other groups and organisations are delivering training and extension programs with vegetable growers in Queensland regions.

Individual industries have irrigation components as part of their overall productivity and sustainability extension programs. For example, DPI&F is working with sweetpotato growers to improve irrigation at establishment, a critical determinant of root yield and quality (Coleman pers. comm.). Australian Horticultural Research is working with lettuce growers in the Lockyer Valley to improve irrigation scheduling using soil moisture monitoring equipment.

WATER SUPPLY INFRASTRUCTURE AND VEGETABLE PRODUCTION

There are numerous scheme dams supplying irrigation water to vegetable growers in all the Queensland vegetable growing regions except Bowen–Mackay and the Granite Belt (Table 19). These water supply schemes are generally administered and operated by SunWater, a Queensland Government Corporation. There are very large storages in the Far North, Burdekin, Wide Bay and Upper Burnett regions.

There are groundwater schemes managed by the Department of Natural Resources and Mines in the Burdekin, Bowen, Bundaberg and Central Lockyer (Table 18). There are also groundwater supplies throughout many of the vegetable growing areas of Queensland that are currently minimally regulated and managed.

Management of both surface and groundwaters in Queensland is undergoing radical changes in regulations, charges, allocations and governing practices. These are so fluid that the details outlined here are likely to be out of date by the time of publication.

The Queensland Government has recently released the Queensland Water Plan 2005–2010.

From the Executive Summary of that Water Plan (Queensland Government 2005)

The Queensland Water Plan 2005–2010 is the Government's program to meet future water needs for consumption and the environment. It outlines strategies and actions to ensure Queensland's economic growth is underpinned by sustainable water resource management. Significant actions include:

- statutory, catchment-based, water resource plans to provide secure water allocations for farms, businesses and homes
- legally protected environmental flows to ensure the health of our rivers and groundwater systems
- water trading to provide access to water and encourage high value use.
- Wild Rivers legislation to protect our pristine rivers
- pricing water to reflect the costs of supply and encourage people to invest in efficient water supply and use
- working with local government and the community to develop regional plans to ensure long term water supply, including new infrastructure
- programs and financial incentives to encourage smarter use of our existing supplies through more efficient use, reuse, and recycling of water
- developing regional strategies to set water quality objectives and to better manage pollution sources and rivers
- monitoring and research to underpin sustainable water management.

Currently, the largest infrastructure development likely to influence supplies of water to vegetable producers is the Burnett River Dam, being constructed at Biggenden, 80 km south-west of Bundaberg. It is planned that this dam will supply in around 124 000 ML/year

Table 19 – Water supply infrastructure in vegetable production areas

Vegetable Report Region	Total vegetable irrigation (ML) c	Principal supply for vegetable production	Major surface infrastructure p	Capacity p	Current level p	Regulated groundwater scheme q	Allocation q	Usage 2003 – 2004 q	Announced allocation (2003–04) q	Total scheme water use (2003–04) q
Far North	8 702	Irrigation scheme, on-farm storage	Tinaroo Falls	438 900 ML	402 900 ML					128 999 ML
Burdekin	8 464	Irrigation scheme, linked groundwater	Burdekin Falls Burdekin weirs	1 860 000 ML 17 540 ML	1 545 000 ML 14 120 ML	Burdekin River GMA	30 531 ML	74 734 ML	Unlimited	755 368 ML
Bowen	16 558	Groundwater				Bowen GMA	17 550 ML	17 061 ML	25–100%	
Central	2 434	On-farm storage, groundwater	Fitzroy River Barrage				11 300 ML	480 ML	100%	18 348 ML
Wide Bay	14 069	Irrigation scheme, groundwater	Fred Haigh Dam Burnett weirs Burnett barrages	562 000 ML 41 100 ML 34 110 ML	273 400 ML 16 220 ML 20 440 ML	Bundaberg GMA	58 305 ML	70 129 ML	25–100%	90 658 ML
Upper Burnett	2 370	Irrigation scheme, on farm storage	B.-Petersen Dam Boondooma Dam Wuruma Dam Upper Burnett weirs	134 900 ML 204 200 ML 165 400 ML 18 210 ML	29 200 ML 66 200 ML 10 200 ML 7 900 ML					36 914 ML
South Coast	9 454	On-farm storage, groundwater, reticulated water	Borumba Dam Maroon Dam	46 000 ML 44 300 ML	42 500 ML 9 360 ML					21 631 ML
Lockyer–Fassifern	29 529	Irrigation scheme, groundwater	Atkinson Dam Lake Clarendon Bill Gunn Dam Moogerah Dam Bremer weirs	30 400 ML 24 300 ML 6 ,940 ML 83 700 ML 280 ML	800 ML 66 ML 450 ML 7 090 ML 116 ML	Central Lockyer GMA	No allocations set	10 031 ML		10 109 ML
Darling Downs	9 503	Irrigation scheme, on-farm storage, groundwater	Beardmore Dam St George weirs Chinchilla Weir	81 700 ML 9 780 ML	45 900 ML 2 230 ML					84 946 ML
Granite Belt	8 668	On-farm storage								

c (ABS 2001)
P (SunWater 2005a); q (DNR&M 2004)

Table 20 – Scheme allocations and seasonal water trades in last 4 years (where regulated and subject to restriction) from NRM annual water statistics

Vegetable Report Region	Water management area or water supply scheme	2003–2004		2002–2003		2001–2002		2000–2001	
		Allocation	Volume traded (ML)	Allocation	Volume traded (ML)	Allocation	Volume traded (ML)	Allocation	Volume traded (ML)
Far North									
	Burdekin River GMA	Unlimited							
Burdekin	Burdekin River WMA			Unlimited		Unlimited			
Bowen–Mackay	Bowen GMA	25–100%		100%		100%		100%	
Central	Fitzroy River Barrage	100%	605.0	100%	2 151	100%	1 273		260
	Bundaberg GMA								
Wide Bay	Lower Burnett & Kolan Rivers WMA	25–100%	1 182.3	15–75%	2 243	30–100%	3 849.9	30–80%	2 308
	Barker-Baranbah WMA								
Upper Burnett	Upper Burnett & Nogoa Rivers WMA	n.a.							
South Coast	Logan River WMA								
	Central Lockyer GMA								
	Lower Lockyer WMA								
Lockyer–Fassifern	Warrill Valley WMA	No allocations set		No allocations set		No allocations set			
Darling Downs	Chinchilla Weir WMA								
Granite Belt									

In 2003/04, some permanent trading of allocations in Wide Bay (38 transfers at a typical price of $1000/ML) and Central (2 transfers at a typical price of $2200/ML) regions.

to vegetable, sugarcane, fruit, macadamia and peanut producers, with target completion by winter 2006 (Burnett Water Ltd 2005).

The current surface and groundwater supply situations and short-term outlook for Queensland vegetable growers (based on availability of actual water, not anticipated regulatory changes), as at 1/10/2005 are:

Good – Far North, Burdekin, South Coast

Moderate to good – Bowen–Mackay, Wide Bay

Moderate – Central, Granite Belt

Poor to moderate – Upper Burnett, Darling Downs

Dire – Lockyer–Fassifern. Vegetable producers in the Lockyer Valley have reacted to water shortages, and changing market conditions, by markedly reducing plantings of crops well supplied by other areas. This is particularly the case with summer crops such as tomatoes, capsicums, and green beans. Many larger producers have elected to concentrate on maintaining plantings of key winter vegetables (e.g. lettuce and broccoli) to ensure continuity through established supply chains. Recent storms in south-east Queensland have generated some flows in the creeks, but there have been no changes in dam storage levels, and little change in alluvial aquifer levels, apart from some recharge close to localised riparian zones.

As can be seen in Table 20, until recently there has been little managed trading of water, or allocations, in most Queensland vegetable production regions. The exceptions are in the Fitzroy River Barrage scheme (Central) and the Bundaberg Groundwater Management Area. The latter scheme is relatively highly regulated compared with most other Queensland schemes, partly because of historical development, and also because tight arrangements are required to manage seawater intrusion along the coast.

WATER ALLOCATIONS AND TRADES

See Table 20

WATER CHARGES AND PRICING

The information provided here is current prior to June 2005.

In regulated areas, a water harvesting charge of $3.00 per megalitre is charged.

There has been significant opposition amongst agricultural and horticultural industries to these proposed changes. Table 22, extracted from the Queensland Water Plan 2005-2010, shows these proposed charges.

At the same time, actual irrigation water pricing for SunWater-administered schemes are currently being reviewed by the Queensland Government. The charges shown in Table 21 have recently been extended until June 2006, or until the new prices are actually set, whichever comes first (SunWater 2005b).

Table 21 – Surface water and groundwater charges for 2004/05 (Department of Natural Resources and Mines 2000; DNR&M 2004)

Vegetable Report Region	Water management area or water supply scheme	Charge per ML allocation, regardless of use	Charge per ML used	Minimum charge
Far North	Mareeba Channel outside relift up to 100 ML	$20.50	$18.00	Additional charge to each Far North scheme: $397.65
	Mareeba Channel outside relift 100–500 ML	$14.00	$16.00	
	Mareeba Channel outside relift over 500 ML	$13.80	$11.50	
	Mareeba Channel inside relift area	$19.00	$25.00	
	Mareeba River supplemented streams	$11.00	$10.00	
	Mareeba River Tinaroo-Barron	$6.80	$6.80	
Burdekin	Burdekin River with nominal entitlement <=25 ML	Total of $93.60 per licensed bore		$93.60
	Burdekin River with nominal entitlement >25 ML	Total of $423.10 per licensed bore		$93.60
	Burdekin Channel	$23.00	$11.40	
	Burdekin River	$7.60	$4.10	
	Burdekin Other	$11.50	$5.70	
Bowen–Mackay	Bowen GMA	nil	$4.40	$93.05
Central	Fitzroy River Barrage	$10.00	$3.00	$191.35
Wide Bay	Bundaberg GMA 1	$3.35	$4.35	$95.15
	Bundaberg GMA 2	Nil	$1.35	$95.15
	Bundaberg channel Interim	$5.16	$44.00	
	Bundaberg channel Final	$29.60	$19.50	
	Bundaberg River Interim	$5.16	$9.20	
	Bundaberg River Final	$8.40	$4.85	
Upper Burnett	Barker-Baranbah	$11.00	$17.25	
	John Goleby Weir	$18.80	$9.00	
	Upper Burnett	$8.50	$7.70	
South Coast	Logan River	$18.50	$13.10	
	Mary Valley	$8.00	$6.00	
Lockyer–Fassifern	Central Lockyer	$13.00	$9.90	
	Lower Lockyer	$14.00	$15.30	
	Mortonvale	$13.00	$19.90	
	Warrill Valley	$17.30	$11.45	
Darling Downs	Upper Condamine	$19.00	$15.80	
	Chinchilla Weir	$14.50	$10.40	
	St George Channel	$19.00	$11.20	
	Beardmore Dam and Thuraggi	$7.28	$6.20	
Granite Belt	on-farm storages			

As part of the Queensland Water Plan 2005–2010, the Queensland Government has recently released a major change to schedules of water charges, to come into effect in July 2006.

Table 22 – Charging for resource access levels and entitlement types

Resource access level 1: urban and essential industry	Water charge = 1.5 cents per kilolitre ($15/ML)	Metered: charges based on metered take Not metered: charges based on estimated take
Resource access level 12: all other industry, e.g. mining and petroleum	Water charge = 1 cent per kilolitre ($10/ML)	Metered: charges based on metered take Not metered: charges based on estimated take
Resource access level 3: irrigation	Water charge = 0.4 cents per kilolitre ($4/ML or annual charge)	Metered: charges based on metered take @ $4/ML Not metered but an allocation specified: charges based on 50% of allocation @ $4/ML or $18/ha Not metered and no allocation specified: $100 annual charge per entitlement Water harvesting only: Metered: metered take @ $4/ML Not metered: annual charge based on size of entitlement: small ($100), medium ($500), and large ($900)
Stock and domestic	Individual licence holders $100 annual charge per licence, with pensioner's discount of 40%	

RECOMMENDATIONS FOR RELATED RESEARCH AND ACTIVITY

- In analysing the statistical data to compile this report, inconsistencies in derived yields, district production figures and subsequent interpretations highlight the need for recent, agreed, verifiable production input and output values. This is not a new issue, but if the vegetable industries wish to present a coherent argument on their value to the Australian economy and their production cost structures, then reliable, up-to-date statistical information is vital. Vegetable industries should investigate how they could best position themselves to access or provide this data.
- The HAL and Growcom study (CDI Pinnacle Management and Street Ryan & Associates 2004) was an invaluable resource document in compiling this report. Their interpretation of the raw statistical data, outlining industry trends, analysis and segregation of industry issues (through consultation and compilation), was an excellent snapshot of Queensland's horticultural industries. This type of report should be regularly repeated, say every 5 years, to provide vegetable industries with reference documents for political and community awareness and internal planning purposes.
- In conducting economic analyses of vegetable industries, including benchmarking, scenario modelling, and comparisons of water use efficiency, the basic building blocks are the individual crop gross margins. In Queensland, we have relied on data that is now up to 5 years old. It is important that crop gross margins are regularly updated (annually, at a minimum), and vegetable industries should investigate how this can be achieved on a regional basis.
- This report suggests significant differences in water use efficiency indices between crops and regions. If vegetable industries are to continue to improve WUE, the

technical reasons for these differences need investigation and communication. This would stimulate effective directions for ongoing research and adoption programs.

- The interaction between water resource use and economic outcomes reported here is a snapshot using currently available data. It is apparent that analyses relying on single values for variables such as water volumes, yields and product prices significantly under-represent the complexity of situations. In arguing a case for allocation of irrigation volumes to vegetable production, or changing irrigation technology, or support for industry adjustment, it is important that there are platforms for evaluating the impacts of fluctuations in variables such as irrigation requirement, input cost, yields and prices. Even rudimentary sensitivity analysis shows how markedly small changes in, say, price and yield affect the value and potential return on investment for vegetable irrigation. Economic models that enable testing of horticultural enterprises, under a range of scenarios, would be excellent tools for vegetable industries and their service providers.
- It is likely that vegetable industries will become increasingly reliant on non-traditional water sources (e.g. recycled water, non-potable aquifers), potentially of lower quality than they are currently using. Readily adoptable guidelines for accessing and using this water would be useful for vegetable industries as they react to changing water resource options.

REFERENCES

ABS (2001) 'Special data request, Value of Agricultural Commodities Database, 2001.' Australian Bureau of Statistics.

ABS (2004) 'Special data request, Value of Agricultural Commodities Database, 2001.' Australian Bureau of Statistics, Canberra.

ABS (2005a) 'Water use on Australian Farms 2002-03.' Australian Bureau of Statistics, Canberra.

ABS (2005b) 'Water Use on Australian Farms 2003-04.' Australian Bureau of Statistics, Canberra.

Bureau of Meteorology (2005) 'Climate averages for Queensland sites.' Bureau of Meteorology,. http://www.bom.gov.au/climate/averages/tables/ca_qld_nos.shtml

Burnett Water Ltd (2005) 'Burnett River Dam.' http://www.burnettwater.com.au/projects/burnett/

CDI Pinnacle Management, Street Ryan & Associates 2004, *Economic contribution of horticulture industries to the Queensland & Australian Economies*, Horticulture Australia Limited

Growcom P/L, HG03039, Brisbane.

Clark D 2003, *2003 Milestone Report*, Rural Water Use Efficiency Initiative, Water for Profit and Queensland Fruit and Vegetable Growers, http://www.nrm.qld.gov.au/rwue/pdf/publications/hortmr2003.pdf

Coleman E (2005) Personal Communication

Coutts J & Bell K 2003, *Evaluation of the Rural Water Use Efficiency Initiative Adoption Program*, Department of Natural Resources and Mines, Queensland, http://www.nrm.qld.gov.au/rwue/pdf/rwuei_program_eval_1.pdf

Department of Natural Resources and Mines (2000) 'Rural water pricing direction notice (No 01) 2000.' http://www.nrm.qld.gov.au/water/reform/pdf/rwp_dir_notice_1_2000.pdf

Department of Natural Resources and Mines (2003) 'Groundwater trends in the Lockyer Valley.'

Department of Natural Resources and Mines (2005) Salinity and Water Quality in Queensland. In. (Brisbane)

Department of Primary Industries and Fisheries (2005) 'Prospects for Queensland's Primary Industries 2004-05 to 2005-06.' http://www2.dpi.qld.gov.au/businessservices/17824.html

DNR&M (2004) 'Annual Water Statistics 2003-2004.' Department of Natural Resources and Mines, Brisbane.

DNR&M (2005) 'Watershed summary water quality statistics.' http://www.nrm.qld.gov.au/watershed/precomp/nf_wqi/index.htm

Gilbey P (2004) 'Bowen Groundwater Situation Report.' Department of Natural Resources and Mines. http://www.sunwater.com.au/pdf/services/Groundwater_at_Bowen_Situation_Report.pdf

Henderson CWL (2003) 'Quantifying high priority reasons for vegetable producers to adopt improved irrigation management strategies.' Department of Primary Industries, Brisbane.

Hunter H, Witting N, Clarke R, Raymond M (2003) 'Water Quality in Sugar Cane Catchments in Queensland.'

Ife D, Skelt K (2004) 'Murray-Darling Basin Groundwater Status 1990-2000: Summary Report.' Murray-Darling Basin Commission, Canberra.

Jackson K (2006) Vegetable industry overview. Personal Communication

Landscape Resource Assessment and Management (2004) 'State of the Region Study Volume 1 - Country to Coast ... a Sustainable Future.' http://www.burnettmarynrm.org.au/c2c/volume3/tech_vol_3a/sobmrr_final_report_v2_08oct04.pdf

McKinna D (2005) 'The Australian vegetable industry at the crossroads.'

NRMSEQ (2004) 'NRM Plan - Water Asset.' http://www.nrmseq.com/plan/Ch7_Water.pdf

Queensland Government (2005) 'Queensland Water Plan 2005-2010.' http://www.nrm.qld.gov.au/water/pdf/qld_water_plan_05_10.pdf

SEQWCG (2004) 'Healthy Land Our Future - Part B: State of our region.'

SunWater (2005a) 'Current Storage Summary.' Sunwater,. http://www.sunwater.com.au/pdf/water/CurrentStorageSummary.pdf

SunWater (2005b) 'Irrigation pricing - Review 2005.' http://www.sunwater.com.au/irrigation_pricing.htm

Water for Profit (2005) 'Water for Profit Information Sheets.' http://www.nrm.qld.gov.au/rwue/factsheets.html

Wilson GG, Adams JC (2004) 'State of the Catchment Report for the Condamine River System - Water.' Condamine Alliance,.

Wylie P (2005) 'Profit from irrigation water at Chinchilla.' Horizon Rural Management. http://www.sunwater.com.au/pdf/services/Coal_Seam_Chinchilla_Brochure.pdf