Department of **Agriculture** and **Food**
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GOVERNMENT OF WESTERN AUSTRALIA

ROYALTIES FOR REGIONS

Comparative assessment of crops to use potential additional water resources in the Warren–Donnelly catchments

Bulletin 4872

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Summary

Through the Royalties for Regions funded Southern Forests Water Futures Project, the Department of Agriculture and Food, Western Australia (DAFWA) undertook a study to understand the economic benefits of developing new water resources in the Warren–Donnelly catchments in the south-west of Western Australia (WA).

The $3.6 million Southern Forests Water Futures Project aims to provide additional irrigation water to meet expansion plans for the Warren–Donnelly catchments in the Manjimup–Pemberton area. This project builds on previous funding of $6.95 million from the Super Towns program and is part of the $300 million Seizing the Opportunity in Agriculture initiative.

The Warren–Donnelly catchments have long been associated with intensive horticultural activities. The major perennial crops are pome fruit (apples and pears), avocados, stone fruit and wine grapes. The major annual crops are ware potatoes, seed potatoes, processing potatoes and brassica crops for the Perth Market over summer. There are emerging new industries including truffles, summer strawberry production, processing lettuce and export broccoli (McGhie 2013).

Expanding horticulture in the Warren–Donnelly catchments could be achieved through the development of a series of dams and an integrated distribution system. A system like this has the potential to harvest an additional 12 gigalitres (GL) of new water resources which could then be used for intensive horticultural production.

The overall construction costs, including setting up pipelines and building dams to harvest 6GL of water, are estimated to be about $40 million (P Ellery [Tasmanian Irrigation] 2015, pers. comm., 15 November). Based on a discount rate of 6%, the benefit cost ratio for the project is 7:1, which means that for every $1 of the $40 million invested, $7 of income is generated over the 20-year life of the project.

Seven crops were studied given their potential to expand into export markets or increase their share of the interstate markets:

- avocados
- strawberries
- broccoli
- apples
- blueberries
- seed potatoes
- sweet corn.

The seven crops were assessed in terms of the target market, gross margin analysis, and yield and price effects under three scenarios where the water resources in the Warren–Donnelly catchments is increased by 6GL:

- Scenario 1: expansion according to existing crop shares
- Scenario 2: expansion of the six crops (excluding sweet corn) with good market information on an equal share of the new water resources (1GL per crop)

- Scenario 3: expansion based on crops considered to have the best future growth rates.

The estimated gross margin return has been derived for Scenario 2, where each of the crops is allocated 1GL of new water resources (Table A). The gross margin return is highest for the apple industry because of the low water use per hectare for this crop and the relatively high gross margin per hectare. The other high gross margin return crops are the blueberry, avocado and strawberry crops. This scenario uses an arbitrary allocation of water resources not based on market demand, unlike Scenario 3.

Table A Estimated water use, potential expansion of each industry if 1GL (1000 megalitres [ML]) of water was made available to each industry and the potential gross margin generated from expansion (Scenario 2)

Crop	Proportion based on suggested water use by crop (%)	New water resources per crop (ML)	New crop area (ha)	Gross margin per hectare (A$)	Gross margin earnings from new cropping areas (A$)
Avocados	16.7	1000	100	50 274	5 028 405
Strawberries	16.7	1000	100	32 371	3 237 747
Apples	16.7	1000	167	44 453	7 410 315
Blueberries	16.7	1000	100	58 035	5 804 661
Seed potatoes	16.7	1000	154	12 440	1 914 229
Broccoli	16.7	1000	181	5 444	989 818
Total	**100**	**6000**	**754**		**24 385 176**

Irrigation requirement figures were derived from the Irrigation Calculator on the DAFWA website (DAFWA 2014b). These water use figures take into account a high demand year and use an irrigation factor of 1.1.

The number of dams built and the size of the distribution pipework will be governed by the expression of interest from businesses interested in being part of the scheme. For the purpose of this report, developing 6GL of new water resources was seen as a practical starting point. If 6GL is developed, it is estimated that between $20.4 million and $27.6 million could be potentially added to the economy of the south-west every year.

There is potential for developing up to 12GL of additional water for irrigated agriculture using a commercial scheme, which could potentially add $40.8 million to $55.2 million of income to the economy of the south-west every year.

The gross margin analysis in this report is a guide to business feasibility. However, businesses will need to undertake their own due diligence suited to their individual circumstances.

1 Introduction

Water resources in the Warren–Donnelly catchments are governed by the Warren–Donnelly Water Allocation Plan. The water allocation plan has specific water harvesting limits for the subcatchments of the Warren and Donnelly rivers. Some of the subcatchments are approaching, or have reached, full allocation for high-reliability water. However, there remains some unallocated water in the surface water system that could be captured and used to significantly increase agricultural production in the area (Department of Water 2012a).

DAFWA analysed the distribution of irrigated agriculture in the Warren–Donnelly catchments in 2014, taking into account the amount of allocated and unallocated water available in each catchment.

Table 1.1 gives a breakdown of the area of current irrigated horticulture and the amount of cleared pasture land in each catchment. In the Donnelly River Catchment, there is 3.7 times the amount of established pasture compared to existing and potential horticulture land. In the Warren River Catchment, there is 7.8 times the amount of established pasture compared to existing and potential horticultural land. There is an excess of cleared pasture land that can be converted to irrigated horticulture. The main limiting factor is the availability of water resources.

Table 1.1 Areas of irrigated horticulture presently operating and potential area of irrigated horticulture in the Warren–Donnelly catchments (Gardiner 2014)

Catchment	Established pasture (ha)	Established irrigated horticulture (ha)	Remaining established pasture (ha)	Established & potential irrigated horticulture (ha)
Donnelly River and tributaries	10 431	1 272	9 239	2 464*
Warren River and tributaries	33 770	2 713	32 343	4 140*

* The increased area of irrigated horticulture is based on available unlicensed water resources allocated at 10ML/ha of land.

The topography and soil type have a direct effect on the suitability of land for irrigated horticulture. Some of the characteristics that can limit irrigation expansion are:

- steep slopes — a slope greater than 15° can affect safe machinery use and increase erosion risk
- lower valley floors, which can increase frost risk and the salinity risk to soils, such as has occurred in the catchments of the Wilgarup River and sections of the upper Donnelly River
- duplex soils with clay subsoil — a clay subsoil can restrict root penetration and increase the risk of localised waterlogging.

2 Potential crops to expand

The Department of Water estimates there is the potential to use up to an additional 12GL of surface water in the Warren–Donnelly catchments by constructing a number of linked dams (F Bunny 2015, pers. comm., 10 November). The dams will harvest and store water to provide a reticulated system to multiple properties.

For the purpose of this report, we chose 6GL as the amount of new available water because we need an estimated cost of building the dams and distribution pipework to calculate the benefit cost ratio for the system over a 20-year period. Tasmanian Irrigation estimates the cost of building the dams and the distribution pipework to be A$40 million (P Ellery [Tasmanian Irrigation] 2015, pers. comm., 12 November).

In 2005, DAFWA investigated a range of horticultural products for the south-west (DAFWA 2005). This list was combined with the list of existing products from the Warren–Donnelly catchments. The combined list was narrowed down through consulting with DAFWA development officers and industry leaders to 10 potential crops:

- avocados
- strawberries
- blueberries
- seed potatoes
- processing potatoes
- apples (new variety targeting export markets)
- sweet corn (extending export product availability)
- broccoli
- processing cabbage
- processing lettuce and spinach.

Further investigation reduced this list to seven products. Processing lettuce and spinach were excluded because of limited information on market opportunities; processing cabbage has a limited supply; processing potatoes have limited information on the full supply chain for processing and uncertainty regarding the new free trade agreement in Korea.

The seven products analysed in this assessment are:

- avocados
- strawberries
- broccoli
- apples
- blueberries
- seed potatoes
- sweet corn.

Successful exporters of sweet corn into high-value markets, such as the United Arab Emirates, need to supply this market over the full 12-month period (J Trandos [sweet corn grower] 2015, pers. comm., 15 November). Sweet corn is included in Scenario 1 because there is some sweet corn currently grown in the Warren–Donnelly catchments. Sweet corn has been removed from scenarios 2 and 3 because of the difficulties in developing a 12-month supply in the Warren–Donnelly catchments.

3 Market and industry review of selected crops

The crops in this assessment were selected because of their potential to be exported, are targeted to interstate markets or have capacity to replace produce from interstate or overseas. The drop in the Australian dollar and the new free trade agreements coming into force are likely to make export markets more attractive. More-detailed market evaluations will be needed to determine if the prices paid in the specific export markets are going to be profitable for the whole supply chain.

3.1 Avocado industry

In WA, avocados are mainly cultivated in the south-west, with Manjimup accounting for more than 80% of the total value (Radhakrishnan 2014). Hass is the dominant variety. The WA industry has two major packing companies — Advanced Packing and Marketing Services (APMS) and Delroy Orchards — who pack, consolidate, distribute and provide management services to several growers. Avocados Australia Limited is the peak national industry body (Radhakrishnan 2014).

The industry has experienced a high growth in planting, increasing almost 600% since 2000. Usually about 50–80% of the total WA production is supplied to Eastern States markets. This percentage varies because alternate bearing affects yield considerably. The total yield in 2012–13 was just under 1900 tonnes (t) and in 2013–14, the yield was about 7500t (A McCarthy [DAFWA] 2015, pers. comm., 10 November) (Radhakrishnan 2014).

Surprisingly, even during record production in 2013–14, the industry experienced a growth in unit value. Production increased by almost 300% from 2012–13, coupled with a 29% increase in unit value (Radhakrishnan 2014). The combination of increased production and the increase in the unit price for avocados has led to a 400% increase in total value to just over $101 million (2012/13 wholesale value), the largest WA fresh fruit or vegetable commodity by value (Radhakrishnan 2014).

Avocado production in WA coincides with South Australia, Victoria and New Zealand production seasons. Therefore, WA and other Australian producers can replace the New Zealand fruit supplying the Eastern States markets. Solid lobbying by Avocados Australia Limited and private distributing companies resulting in supermarket policy changing to source more fruit locally was an added advantage in 2012/13 (Radhakrishnan 2014).

A new avocado marketing company, The Avolution, was launched in New South Wales on 12 June 2013 to ensure a year-round national supply of Australian avocado (Barnard & Groucher 2014). The Avolution represents growers in WA, Queensland and Victoria and currently supplies 20% of Australia's avocados. APMS in WA is supplying fruit for those months when there is no production in the Eastern States, which reduces the supermarket dependence on New Zealand for off-season supply (Radhakrishnan 2014).

In the WA domestic market, avocado is one of the few industries which realised a positive growth in real prices for the past couple of years. This growth is a result of the solid market gains into Eastern States markets and recent small gains into

overseas markets, resulting in a relatively stable supply of fruit in the local market (Radhakrishnan 2014).

On average, price increased by about $45 per tonne per year over the last seven years. Moreover, avocado is the only WA industry which realised a price premium for their product — WA avocados realised 25% more wholesale unit price than the Eastern States product during 2013 (Radhakrishnan 2014).

Increased avocado production would likely be aimed at the interstate and domestic market because there is still an increasing demand for avocados from these markets. However, WA avocados are currently being exported and recent changes brought about by free trade agreements could create more potential for exports in the future (Barnard & Groucher 2014).

The avocado industry is growing rapidly and Table 3.1 gives an overview of the industry in 2013. Most of the avocados grown in WA are destined for the Eastern States markets and there is an export market for avocados in Singapore and Thailand.

Table 3.1 Overview of the WA avocado industry in 2013 (source: Radhakrishnan 2014)

Industry characteristic	Unit/value or source
WA production (t)	18 578
WA consumption (t)	4 798
Import from overseas (t)	19
Supply from Eastern States (t)	1 003
Supply to Eastern States (t)	14 202
Wholesale value ($/t)	5 130
Major import source	New Zealand
Major supply destination in Australia	New South Wales and Victoria
Major export destination	Singapore and Thailand

3.1.1 Opportunities

The major opportunities for the industry:

- Export demand (overseas and interstate) is the major profit driver and a 10% increase in export demand may create a 6% increase in farm profitability.
- Vertical and horizontal integration has led to a well-organised industry structure.
- The industry has adopted improved post-harvest handling and marketing practices.
- There is good after sales services in the overseas markets.
- There is a good use of technology to track the product through the supply chain.

- The product is recognised in the marketplace as highly nutritional.
- There is a low level of pest and diseases affecting avocado crops in WA.
- WA has a good seasonal advantage because the production season is different from Queensland, which is a major Australian producer.
- The industry has up-to-date statistics on supply volumes, flow and prices. There is a better flow of information for the production and marketing information within the industry.
- The south-west has a climatic advantage for producing high quality avocados. Avocados from the Manjimup Shire are the last in the market, which usually means higher prices.
- Per capita consumption of avocado in WA is low at 1.9kg, whereas it is 2.8kg for the whole of Australia. Therefore, there are opportunities to expand consumption.
- Avocado is a relatively new food product in Australia; therefore it is unlikely that there will be a sudden shift away from the crop in the near future.
- Strict quality control and stringent practices in the industry has led to a good reputation. Australia's packing companies have developed quality assurance standards that comply with stringent international quality assurance schemes (J Francheski [avocado grower] 2016, pers. comm., 12 January).

3.1.2 Challenges

The major challenges for this industry are:

- increases in hired labour costs and the value of other inputs — a 10% increase in the hired labour costs or value of other inputs (excluding hired labour, capital, land, transport, fuel, fertiliser and chemicals) may reduce farm profitability by 2% (Radhakrishnan 2014)
- increases in plantings may lead to oversupply if new markets are not developed
- the fruit is very sensitive to incorrect handling practices
- trees in a vegetative growth pattern or a production growth pattern affects the avocado production per hectare
- avocados need high quality soil and water.

3.1.3 Economic analysis

A gross margin analysis was undertaken for an 'average' avocado enterprise in the Warren–Donnelly catchments (Table 3.2). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an 'average' enterprise size.

Table 3.2 outlines the possible revenue from the sale of the avocados ($2 574 000), the operating costs for producing the avocados ($563 040) and the resulting gross margin ($2 010 960) for a 40ha enterprise. It also outlines the development costs ($1 331 539) that will be incurred in the first five years of establishing this enterprise.

Table 3.2 Gross margin analysis for a 40ha avocado enterprise (source: Gartrell 2015b)

Item	Total	Value ($/ha)
Revenue (16.5t/ha @ $3.90/kg)	$2 574 000	$64 350
Variable costs	$563 040	$14 076
Gross margin (revenue minus variable costs)	$2 010 960	$50 274
Variable cost breakdown		
Pruning, mowing & operating	$42 594	$1 065
Pest & disease control	$65 287	$1 632
Fertiliser & testing	$80 150	$2 004
Irrigation operating, fuel & electricity	$100 500	$2 513
Harvest	$121 960	$3 049
Management & consultant costs	$95 000	$2 375
Other costs	$57 909	$1 438
Subtotal	**$563 040**	**$14 076**
Development costs for the first 5 years		
Plants & planting	$299 071	$7 477
Irrigation & dam construction costs	$315 000	$7 875
Plant & machinery	$378 250	$9 456
Site development costs	$339 217	$8 480
Subtotal	**$1 331 538**	**$32 288**

In the sensitivity analysis, the yield of avocados ranged from 14.5 to 18.5 tonnes per hectare (t/ha) and the price per kilogram of avocados ranged from $2.90 to $4.90. This range in yield and price resulted in a range of gross margins per hectare of $27 974 to $76 574, with an average gross margin per hectare of $50 274 (Table 3.3).

Table 3.3 Gross margin sensitivity analysis for avocado production

Price/kg (A$/kg)	Saleable yield (t/ha)				
	14.5 (80%)	15.5 (90%)	16.5 (100%)	17.5 (110%)	18.5 (120%)
$2.90 (74%)	$27 974	$30 874	$33 774	$36 674	$39 574
$3.40 (87%)	$35 224	$38 624	$42 024	$45 424	$48 824
$3.90 (100%)	$42 474	$46 374	$50 274	$54 174	$58 074
$4.40 (113%)	$49 724	$54 124	$58 524	$62 924	$67 324
$4.90 (126%)	$56 974	$61 874	$66 774	$71 674	$76 574

3.2 Strawberry industry

Strawberries are produced throughout the year in WA, with supply peaks during winter. The main varieties grown are Camarosa and Festival and the major producing area is Wanneroo. Strawberry consumption has increased by 11% since 2012 (Radhakrishnan 2014).

Average wholesale price declined by about $113/t each year over the last seven years (Radhakrishnan 2014). Prices peak during April and May and decline during winter when the WA production season starts. The prices for 2013 were below average, except in October (Radhakrishnan 2014).

Table 3.4 gives an overview of the strawberry industry, the level of production and the major markets. Over half the strawberries are consumed locally, with the remainder being sold interstate or exported to Singapore and Thailand.

Table 3.4 Overview of the strawberry industry in 2013 (DAFWA 2014c)

Industry characteristics	Unit/value or source
WA production (t)	11 250
WA consumption (t)	6 233
Import from overseas (t)	80 (Perth Market Authority)
Supply from Eastern States (t)	1 003
Supply to Eastern States (t)	4 475
Wholesale value (A$/t)	7 138
Major export destination	Singapore and Thailand

3.2.1 Opportunities

Export demand is the major profit driver for the industry. A 10% increase in export demand may create an 18% increase in farm profitability. The same increase in domestic demand may increase the industry profitability by 5% (Radhakrishnan 2014).

Extra strawberry production should be aimed at export markets because domestic and interstate markets are well supplied. Strawberries are currently being exported to Singapore, the United Arab Emirates, Thailand and Malaysia. It is worth investigating the capacity of these markets to take more WA strawberries. Because of the perishable nature of the crop, air freight and the associated costs will be necessary (Radhakrishnan 2014).

3.2.2 Challenges

The major challenge is managing a fall in retail margins. A 10% fall may reduce farm profitability by 5% because a fall is directly passed onto growers. Other challenges include increases in the value of other inputs, hired labour and reductions in the value of imports (Radhakrishnan 2014).

3.2.3 Economic analysis

A gross margin analysis was undertaken for an average strawberry enterprise in the Warren–Donnelly catchments (Table 3.5). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.5 lists the possible revenue from the sale of strawberries ($3 250 000), the operating costs for producing the strawberries ($2 731 920) and the resulting gross margin ($518 080) for a 16ha enterprise. It also outlines the development costs ($1 960 000) that will be incurred in the first year of establishing this enterprise.

Table 3.5 Gross margin analysis for a 16ha strawberry enterprise (Radhakrishnan 2015)

Item	Total	Value ($/ha)
Revenue (156 250 punnets/ha @ $1.30/punnet)	$3 250 000	$203 125
Variable costs	$2 731 920	$170 754
Gross margin (revenue minus variable costs)	$518 080	$32 371
Variable cost breakdown		
Land preparation	$80 960	$5 060
Planting	$325 440	$20 340
Irrigation	$19 200	$1 200
Fertiliser	$33 744	$2 109
Disease and pest control	$242 208	$15 138
Weed control	$368	$32
Harvesting and marketing	$2 030 000	$126 875
Subtotal	**$2 731 920**	**$170 754**
Development costs incurred in the first year		
Frames	$960 000	$60 000
Plastic covers	$400 000	$25 000
Irrigation	$130 000	$8 125
Plant and machinery	$220 000	$13 750
Shed/packing facility	$250 000	$15 625
Subtotal	**$1 960 000**	**$122 500**

In the sensitivity analysis, the yield of strawberry punnets per hectare ranged from 125 000 to 187 500 and the price per punnet of strawberries ranged from $1.10 to $1.50. This range in yield and price resulted in a range of gross margins per hectare of –$33 254 to $110 496 with an average gross margin per hectare of $32 371 (Table 3.6).

Table 3.6 Gross margin sensitivity analysis for strawberry production

Price/punnet (A$/kg)	Saleable yield (kg)				
	125 000 (80%)	140 625 (90%)	156 250 (100%)	171 875 (110%)	187 500 (120%)
$1.10 (85%)	–$33 254	–$16 067	$1 121	$18 309	$35 496
$1.20 (92%)	–$20 754	–$2 004	$16 746	$35 496	$54 246
$1.30 (100%)	–$8 254	$12 059	$32 371	$52 684	$72 996
$1.40 (108%)	$4 246	$26 121	$47 996	$69 871	$91 746
$1.50 (115%)	$16 746	$40 184	$63 621	$87 059	$110 496

3.3 Broccoli industry

Broccoli is produced in WA all throughout the year. Supply from Perth comes during winter, while most of the supply from Manjimup comes during summer. Export trade has not been a major factor for the industry since the decline in export about 10 years ago. The export trade for broccoli may increase with the reduction of tariffs made possible through the free trade agreements and the shift in the foreign exchange rate (DAFWA 2014a).

Table 3.7 gives an overview of the broccoli industry, the level of production and the major markets. Most of the broccoli is consumed locally, with a small amount exported to Singapore.

Table 3.7 Overview of the broccoli industry in 2013 (source: DAFWA 2014a)

Industry characteristics	Unit/value or source
WA production (t)	5 499
WA consumption (t)	8 854
Supply from Eastern States (t)	3 354
Wholesale value ($/t)	2 730
Major export destination	Singapore

3.3.1 Opportunities

Export demand is the major profit driver for broccoli. A 10% increase in export may increase farm profitability of broccoli by 1.8% (Radhakrishnan 2014).

Increased broccoli production should be aimed at an export market because domestic and interstate markets are well supplied with current production from WA. China, Korea and Japan are possible markets for high quality produce. These markets are price sensitive and rely on favourable exchange rates. Because of the perishable nature of the crop, air freight and the associated costs will be necessary (Trade Investment Queensland 2015).

3.3.2 Challenges

Increases in the cost of other inputs are the major challenge for the broccoli industry; a 10% increase can reduce farm profitability by 3% (Radhakrishnan 2014).

3.3.3 Economic analysis

A gross margin analysis was undertaken for an average broccoli enterprise in the Warren–Donnelly catchments (Table 3.8). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.8 lists the possible revenue from the sale of broccoli ($1 098 520), the operating costs for producing the broccoli ($880 760) and the resulting gross margin ($217 760) for a 40ha enterprise. It also outlines the operating costs for the enterprise in a year-in, year-out gross margin budget. The development costs ($918 000) are incurred in the first year because broccoli is an annual crop.

Table 3.8 Gross margin analysis for a 40ha broccoli enterprise (source: Gartrell 2015c)

Item	Total	Value ($/ha)
Revenue (1630, 9kg cartons/ha @ $16.90/carton)	$1 098 520	$27 463
Variable costs	$880 760	$22 019
Gross margin (revenue minus variable costs)	$217 760	$5 444
Variable cost breakdown		
Chemicals	$52 000	$1 300
Fertiliser	$115 000	$2 875
labour	$99 280	$2 482
Irrigation	$39 520	$988
Transport	$28 440	$711
Harvest labour	$90 720	$2 268
Packaging & commission	$244 600	$6 115
Seedlings	$211 200	$5 280
Subtotal	**$880 760**	**$22 019**
Development costs in the first year		
Tractors 100,80 & 50 hp+	$300 000	$7 500
Sprayers & spreader	$42 000	$1 050
Cultivation equipment	$26 000	$650
Shed	$175 000	$4 375
Forklift, utility, motorbikes	$75 000	$1 875

Item	Total	Value ($/ha)
Centre pivots, generators & spares	$141 000	$3 525
Pumps	$45 000	$1 125
Other irrigation equipment	$114 000	$2 850
Subtotal	**$918 000**	**$22 950**

In the sensitivity analysis, the yield of broccoli cartons per hectare ranged from 1300 to 1950 and the price per carton of broccoli ranged from $13.20 to $19.50. This range in yield and price resulted in a range of gross margins per hectare of –$4 939 to $15 926, with an average gross margin per hectare of $5448 (Table 3.9).

Table 3.9 Gross margin sensitivity analysis for broccoli production

Price (A$/carton)	Saleable yield (cartons)				
	1 300 (80%)	1 470 (90%)	1 630 (100%)	1 790 (110%)	1 950 (120%)
$13.20 (80%)	–$4 939	–$2 695	–$583	$1 529	$3 641
$15.20 (90%)	–$2 339	$245	$2 677	$5 109	$7 541
$16.90 (100%)	–$129	$2 744	$5 448	$8 152	$10 856
$18.60 (110%)	$2 081	$5 243	$8 219	$11 195	$14 171
$19.50 (120%)	$3 251	$6 566	$9 686	$12 806	$15 926

3.4 Apple industry

Additional apple production should be aimed at an export market because domestic and interstate markets are well supplied from the Manjimup region. Export opportunities are likely to increase with the release of the new apple variety that should appeal to the Asian market and the changes resulting from the new free trade agreements (H Giblett & B Darbyshire [apple growers] 2015, pers. comm., 10 November).

DAFWA surveyed apple growers in the south-west to identify opportunities and challenges for the industry. The important findings of the survey are presented below (Ghose & Portman 2006).

3.4.1 Opportunities

The main opportunities for the apple industry:

- Appreciation of the Australian dollar has significant ramifications for fruit exports. Growers are likely to be profitable in the long term if they can export competitively at the fundamental value of the Australian dollar which is estimated to be about US$0.70 (Ghose & Portman 2006).
- Large farm businesses with cool storage, packing and marketing facilities, and small family farms are likely to be more profitable than the mid-sized farms.

- Choice of product portfolio and regular replanting is necessary to maintain profitability. The current trend is to replace apples with avocados, although most farmers are interested in planting new apple varieties when they become available.

3.4.2 Challenges

The main challenges for the apple industry:

- About one-third of apple growers in the south-west are unable to maintain profitability.
- Increasing labour costs and lower farm-gate prices are putting severe pressure on margins of deciduous fruit enterprises.
- Of the growers surveyed, 60% use mainly family labour for their enterprise and they find external labour cost to be prohibitively expensive.
- Of the growers surveyed, half stated it was unlikely their children would take over the family fruit growing business. Under these circumstances, the main choice left to growers is to sell their farms when they retire.
- Average intensity of production is 40t/ha; however, 50t/ha may be required to sustain future profitability.
- Quality of the deciduous fruit is another important concern. The break-even pack-out — the total amount of fruit that is put into cartons and sold, compared to the total amount of fruit harvested — is considered by most respondents to be 65% for apples.

3.4.3 Economic analysis

A gross margin analysis was undertaken for an average apple producing enterprise in the Warren–Donnelly catchments (Table 3.10). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.10 lists the revenue possible from the sale of apples ($2 715 000), the operating costs for producing the apples ($941 884) and the resulting gross margin ($1 773 116) for a 40ha enterprise. It also outlines the development costs ($2 876 880) that will be incurred in the first five years of establishing this enterprise.

Table 3.10 Gross margin analysis for a 40ha apple producing enterprise (source: Gartrell 2015a)

Item	Total	Value ($/ha)
Revenue (50t/ha @ $1.36/kg)	$2 715 000	$68 000
Variable costs	$941 884	$23 547
Gross margin (revenue minus variable costs)	$1 773 116	$44 453
Variable cost breakdown		
Pruning, mowing & operating	$225 020	$5 626
Pest control	$195 081	$4 877
Fertiliser & testing	$79 680	$1 992
Irrigation operating, fuel & electricity	$115 560	$2 890
Harvest	$153 000	$3 825
Management & consultancy	$102 640	$2 566
Other costs	$70 903	$1 773
Subtotal	**$941 884**	**$23 547**
Development costs in the first 5 years		
Plants & planting	$1 440 000	$36 000
Trellising	$304 800	$7 620
Irrigation	$405 500	$10 138
Plant & machinery	$493 000	$12 325
Site development costs	$233 580	$5 840
Subtotal	**$2 876 880**	**$71 923**

In the sensitivity analysis, the yield of apples per hectare ranged from 40t to 60t and the price per kilogram of apples ranged from $1.09 to $1.63. This range in yield and price resulted in a range of gross margins per hectare of $19 973 to $74 373, with an average gross margin per hectare of $44 453 (Table 3.11).

Table 3.11 Sensitivity analysis for apple production

	Saleable yield (t/ha)				
Price (A$/kg)	40t (80%)	45t (90%)	50t (100%)	55t (110%)	60t (120%)
$1.09 (80%)	$19 973	$25 413	$30 853	$36 293	$41 733
$1.22 (90%)	$25 413	$31 533	$37 653	$43 773	$49 893
$1.36 (100%)	$30 853	$37 653	$44 453	$51 253	$58 053
$1.50 (110%)	$36 293	$43 773	$51 253	$58 733	$66 213
$1.63 (120%)	$41 733	$49 893	$58 053	$66 213	$74 373

3.5 Blueberry industry

The Australian blueberry industry is expanding rapidly and has huge potential. Blueberries are a popular and well-flavoured food that is sought by the health conscious consumer. Fresh blueberries are available from June to April and frozen blueberries are available all year round. Each year, Australian growers produce 6000t of blueberries with a farm-gate value of A$120 million. Of these, 75% is sold fresh within Australia, 15% is exported to Asia and Europe, and 10% is processed, mainly as frozen product (Australian Blueberry Growers Association 2016).

In the export market, Chile, Argentina and China are emerging as serious competition because they have lower labour and production costs. The international competiveness of the Australian industry is affected by factors such as the value of the Australian dollar and pest issues, such as Queensland Fruit Fly. Australian blueberries were first grown commercially in Victoria in 1974. Plantings began 10 years later on the north coast of New South Wales. In 2004, the Northern Rivers region of New South Wales — from Coffs Harbour to the Queensland border — produced over 75% of Australia's blueberries on three major farms. A cooperative of more than 50 growers in this region has now become a significant blueberry producer (Australian Blueberry Growers Association 2016).

Production in southern Australia and Tasmania is also increasing. With a growing interest in organic produce from consumers, a significant percentage of members are now certified as organic or bio-dynamic, particularly in Victoria (Australian Blueberry Growers Association 2016).

Additional blueberry production has the potential to displace interstate produce on the domestic market and has the possibility of exporting into Japan, the United Arab Emirates, Singapore and China. Because of the perishable nature of the crop, air freight and the associated costs will be necessary (M Tosano [blueberry grower] 2015, pers. comm., 11 December).

3.5.1 Economic analysis

A gross margin analysis was undertaken for an average blueberry enterprise in the Warren–Donnelly catchments (Table 3.12). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.12 lists the revenue possible from the sale of the blueberries ($1 275 000), the operating costs for producing the blueberries ($1 149 830) and the resulting gross margin ($290 170) for a 5ha enterprise. It also outlines the operating costs and development costs ($805 192) that will be incurred in the first five years of establishing this enterprise.

Table 3.12 Gross margin analysis for a 5ha blueberry enterprise (source: Wilks & Simpson 2015)

Item	Total	Value ($/ha)
Revenue ($36/tray x 8000 trays/ha)	$1 275 000	$288 000
Variable cost	$1 149 830	$229 966
Gross margin (revenue minus variable costs)	$290 170	$58 034
Variable cost breakdown		
Irrigation	$8 905	$1 781
Disease control & fungicides	$2 180	$439
Insect control insecticides	$3 485	$697
Nutrition	$7 650	$1 530
Pruning & thinning	$23 430	$4 687
Machinery	$28 550	$5 710
Marketing	$220 060	$44 012
Packing materials	$176 000	$35 200
Picking & packing	$673 410	$134 682
Subtotal	**$1 149 830**	**$229 966**
Development costs in the first 5 years		
Site establishment	$69 876	$17 469
Plants and planting	$79 796	$19 949
Netting – bird netting	$250 000	$50 000
Irrigation	$58 120	$14 530
Plant & machinery	$140 000	$35 000
Packing facility	$207 400	$51 850
Subtotal	**$805 192**	**$188 798**

In the sensitivity analysis, the yield of blueberries per hectare ranged from 7000 to 8500 trays and the price per tray of blueberries ranged from $30 to $42. This range in yield and price resulted in a range of gross margins per hectare of –$19 966 to $127 034, with an average gross margin per hectare of $58 034 (Table 3.13).

Table 3.13 Gross margin sensitivity analysis for blueberry production

Price (A$/tray)	Saleable yield (trays/ha)				
	7 000 (88%)	7 500 (94%)	8 000 (100%)	8 250 (103%)	8 500 (106%)
$30 (83%)	$–19 966	$4 966	$10 034	$17 534	$25 034
$33 (92%)	$1 034	$17 534	$34 034	$42 284	$50 534
$36 (100%)	$22 034	$40 034	$58 034	$67 034	$76 034
$39 (108%)	$43 034	$62 534	$82 034	$91 784	$101 534
$42 (117%)	$64 034	$85 034	$106 034	$116 534	$127 034

3.6 Seed potato industry

In 2012 and 2013, WA was responsible for 78–96% of Australian seed potato exports. Indonesia and Mauritius were the main destinations, with exports to these two countries in 2012 valued at A$1.8 million and A$1.7 million, respectively. In 2013, Indonesia's imports of seed potatoes from WA increased by 10% in volume and 12% in value (Mattingley 2013).

Although the Netherlands seed potato industry is the world's largest seed industry in terms of value and volume of seed produced annually, there is a worldwide shortage of quality seed potatoes. Using poor quality seed potatoes leads to reduced crop yields and poor tuber quality. This situation limits the expansion of the fresh and processing potato industries in many developing countries (Mattingley 2013).

There are currently 38 seed potato growers in WA, producing from 412ha of land primarily in the south-west (Mattingley 2013).

Seed potato production in WA is subject to the WA Certified Seed Potato Scheme administered by AGWEST Plant Laboratories in DAFWA. The WA Certified Seed Potato Scheme ensures that WA-produced seed potatoes meet all export market requirements (Mattingley 2013).

All modern seed potato certification schemes are based on a 'flow through' principle in which material of high health status, generation zero (G0), enters the top end of the seed scheme as minitubers, microtubers or plantlets produced in accredited laboratories from pathogen-tested tissue culture stock (DAFWA 2015).

Because WA domestic seed is produced to order, major varieties need to be ordered 18 months before delivery to enable the seed producer to assign seed for multiplication. Minor varieties may require more time for suitable quantities to be multiplied. Domestic seed plant heath certificates for interstate sales are issued by the AGWEST Plant Laboratories (DAFWA 2015).

Domestic seed is either graded or packed by the seed producer or by packing houses. Buyers arrange pick-up from the grading premises. Appropriate post-harvest storage is usually arranged by the seed buyer through a third-party cool storage provider (DAFWA 2015).

3.6.1 Opportunities

New seed potato production should be aimed at export markets, such as Mauritius, Indonesia, Malaysia, Thailand and Korea. WA is well-positioned in terms of product quality and transport costs to make WA seed potatoes competitive in these markets (DAFWA 2015).

Asia is a relatively small but growing market for European seed exporters. WA is ideally placed to service the Asian market and the WA seed potato industry has been expanding in response to the growing demand from South-East Asian processing factories that require seed of the Atlantic variety for their growers (DAFWA 2015).

Traditionally, growth in WA's horticultural sector has come primarily from existing growers, with industries consolidating around fewer, larger growers. Major opportunities in seed potato growing are:

- the fall in the value of the Australian dollar against the euro and the British pound which means WA seed potatoes are more competitive against Dutch and Scottish producers
- continued growth in demand from South-East Asian potato processors for certified Atlantic seed
- emerging new marketing entities in WA to export seed potatoes
- proven profitability of growing export seed
- the 2008 discovery of potato cyst nematode in a Victorian seed production area which limits the trade of seed potatoes from Victoria
- potential for new market development in the Middle East for supplying Dutch and Scottish varieties on a counter-seasonal basis to the northern hemisphere (DAFWA 2015).

An expanding seed potato industry in WA will require access to land and water. The south-west region has significant areas of land which were historically used for cauliflower production and processing potato production. The contraction of WA's export cauliflower industry and the fall in production of processing potatoes since Simplot departed Manjimup in 1999 has left significant spare capacity in horticultural land in areas suitable for seed potato production (DAFWA 2015).

The increase in the demand for seed potatoes needs to be matched by increasing production; however, high pest and disease pressures hamper seed potato production in Asia, particularly in tropical and subtropical regions. Asian potato growers need god quality seed potatoes to produce a profitable crop (DAFWA 2015).

3.6.2 Economic analysis

A gross margin analysis was undertaken for an average seed potato enterprise in the Warren–Donnelly catchments (Table 3.14). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.14 lists the revenue possible from the sale of seed potato ($1 589 440), the operating costs for producing the seed potato ($1 091 840) and the resulting gross margin ($497 600) for a 40ha enterprise. It also outlines the operating costs for the enterprise on a year-in, year-out gross margin. The development costs ($918 000) are incurred in the first year because seed potato is an annual crop.

Table 3.14 Gross margin analysis for a 40ha seed potato enterprise (DAFWA 2015)

Item	Total	Value ($/ha)
Revenue (44t/ha @ $903/t)	$1 589 440	$39 736
Variable costs	$1 091 840	$27 296
Gross margin (revenue minus variable costs)	$497 600	$12 440
Variable cost breakdown		
Land preparation and planting	$7 400	$185
Labour	$86 080	$2 152
Crop inputs	166 760	$4 169
Irrigation	$39 080	$977
Harvesting	$35 480	$887
Seed certification	$16 080	$402
Grading and cold storage	$404 200	10 105
Levies	$9 200	230
Freight to Perth	$78 920	$1 973
Shipping costs	$165 240	$4 131
Other	$83 400	$2 085
Subtotal	**$1 091 840**	**$27 296**
Development costs in the first year		
Tractors 100,80 & 50 hp+	$300 000	$7 500
Sprayers & spreader	$42 000	$1 050
Cultivation equipment	$26 000	$650
Shed	$175 000	$4 375
Forklift, utility, motorbikes	$75 000	$1 875
Centre pivots, generators & spares	$141 000	$3 525
Pumps	$45 000	$1 125
Other irrigation equipment	$114 000	$2 850
Subtotal	**$918 000**	**$22 950**

In the sensitivity analysis, the yield of seed potatoes per hectare ranged from 25.1t to 58.6t and the price per tonne of seed potatoes ranged from $570 to $1330. This range in yield and price resulted in a range of gross margins per hectare of $–12 989 to $50 642, with an average gross margin per hectare of $12 440 (Table 3.15).

Table 3.15 Gross margin sensitivity analysis for seed potato production

Price (A$/t)	Saleable yield (t/ha)				
	25.1t (60%)	33.5t (80%)	41.8t (100%)	50.2t (120%)	58.6t (140%)
$570 (60%)	–$12 989	–$8 201	–$3 470	$1 318	$6 106
$760 (80%)	–$8 220	–$1 836	$4 472	$10 856	$17 240
$950 (100%)	–$3 451	$4 529	$12 440	$20 394	$28 374
$1140 (120%)	$1 318	$10 894	$20 356	$29 932	$39 508
$1330 (140%)	$6 087	$17 529	$28 298	$39 470	$50 642

3.7 Sweet corn industry

AgEconPlus (2014) investigated markets for sweet corn in Malaysia and the United Arab Emirates (UAE). This study identified investment options and return on investment analysis over a three-year investment plan. It revealed that Australian investment in the Malaysian sweet corn market is not warranted because the country is self-sufficient in sweet corn. The report provided a sweet corn investment plan for the UAE.

According to AgEconPlus (2014), Australia has a potential comparative advantage in sweet corn exports because production is mechanised and a year-round supply program has been developed. Value-added products have shown potential on the domestic market and may be applicable to overseas markets. AgEconPlus undertook a UAE market analysis for exports of sweet corn. Access to the UAE market for vegetables is straightforward, although it requires phytosanitary certificates. A bilateral relationship is well-developed and growing between Australia and the UAE and in 2012, the UAE were the third largest purchaser of Australian fresh vegetables (AgEconPlus 2014).

New sweet corn production should be aimed at an export market, such as Korea and other high-value markets. Indonesia, Malaysia and Thailand are self-sufficient in sweet corn production and so imported product would have to be value-added to gain entry into these markets. Countries such as UAE, Saudi Arabia and Japan, which import large quantities of produce and are willing to pay for premium produce, are more likely to pay the prices required to make sweet corn production viable (AgEconPlus 2014).

3.7.1 Economic analysis

A gross margin analysis was undertaken for an average sweet corn enterprise in the Warren–Donnelly catchments (Table 3.16). It is based on a modelled enterprise using estimated averages which were validated with growers. The area is based on an average enterprise size.

Table 3.16 lists the revenue possible from the sale of fresh sweet corn ($946 000), the operating costs for producing the sweet corn ($513 800) and the resulting gross margin ($432 200) for a 40ha enterprise. It also outlines the operating costs for the enterprise in a year-in, year-out gross margin budget. The development costs ($918 000) are incurred in the first year because sweet corn is an annual crop.

Table 3.16 Gross margin analysis of a 40ha fresh sweet corn enterprise (source: Industry & Investment 2009)

Item	Total	Value ($/ha)
Revenue (2150 cartons/ha @ $11.00 per 16.5kg carton	$946 000	$23 650
Variable costs	$513 800	$12 845
Gross margin (revenue minus variable costs)	$432 200	$10 805
Variable cost breakdown		
Seed	$12 600	$315
Machinery costs	$12 400	$310
Irrigation	$25 000	$625
Fertiliser	$35 280	$882
Disease & pest control	$15 880	$398
Weed control	$3 000	$75
Casual labour	$111 120	$2 778
Harvesting – carton costs	$50 400	$1 260
Marketing	$248 120	$6 203
Subtotal	**$513 800**	**$12 845**
Development costs in the first year		
Tractors 100,80 & 50 hp+	$300 000	$7 500
Sprayers & spreader	$42 000	$1 050
Cultivation equipment	$26 000	$650
Shed	$175 000	$4 375
Forklift, utility, motorbikes	$75 000	$1 875
Centre pivots, generators & spares	$141 000	$3 525
Pumps	$45 000	$1 125
Other irrigation equipment	$114 000	$2 850
Subtotal	**$918 000**	**$22 950**

In the sensitivity analysis, the yield of sweet corn cartons per hectare ranged from 1850 to 2450 and the price per carton of sweet corn ranged from $9 to $13. This range in yield and price resulted in a range of gross margins per hectare of $3 805 to $19 005, with an average gross margin per hectare of $10 805 (Table 3.17).

Table 3.17 Gross margin sensitivity analysis for sweet corn production

Price (A$/carton)	Saleable yield (cartons/ha)				
	1850 (60%)	2000 (80%)	2150 (100%)	2300 (120%)	2450 (140%)
$9 (60%)	$3 805	$5 155	$6 505	$7 855	$9 205
$10 (80%)	$5 655	$7 155	$8 655	$10 155	$11 655
$11 (100%)	$7 505	$9 155	$10 805	$12 455	$14 105
$12(120%)	$9 355	$11 155	$12 955	$14 755	$16 555
$13 (140%)	$11 205	$13 155	$15 105	$17 055	$19 005

4 Analysing economic return from a 6GL expansion

In analysing the economic return generated from the supply of new water resources, three scenarios were used. In each scenario, 6GL of new water is made available to irrigate horticultural crops.

4.1 Scenario 1

Six gigalitres (6000ML) of additional water is made available for new crop production and the projected new plantings are proportional to current industry profiles.

To determine the current area planted to each irrigated crop in the Warren–Donnelly catchments, the total production of each major crop for 2014 was identified and then divided by the crop's average yield to determine the number of hectares planted for each crop. The proportion of each crop grown was determined by using Agricultural Produce Commission (APC) figures, Avocado Australia Limited information and expert opinion from DAFWA development officers and industry leaders.

Table 4.1 lists the main crops, area planted and proportion of total water use by each crop type. Seasonal crop water use varies from 1ML/ha for wine grapes to 10ML/ha for avocado and strawberry production. Production in the Warren–Donnelly catchments was estimated by tabulated APC data (area planted). Water use was calculated using the Irrigation Calculator (DAFWA 2014b). Data from the Royalty for Regions funded Water Efficiency project and DAFWA development officers were consulted to validate the figures.

The largest single crop water use is potato production (40.6% of water use), followed by avocado production (35.6% of water use). The total gross margin earnings for all of the potential new cropping areas are estimated to be $20.4 million per year (Table 4.2).

Table 4.1 Estimated distribution of irrigated horticultural crops in the Warren–Donnelly catchments and their proportional water use as a percentage of total water use in the combined catchments

Crop	Area planted based on average yield per hectare (ha)	Estimated seasonal irrigation requirement (ML/ha)	Average water use by planted area (ML)	Proportion based on water use by crop (%)
Potatoes	1 474	6.5	9 581	40.6
Avocados	840	10	8 400	35.6
Vegetables	500	5.5	2 750	11.7
Wine grapes	400	1	400	1.7
Pome fruit	330	6	1 980	8.4
Strawberries	38	10	380	1.6
Stone fruit	11	6	66	0.3
Sweet corn	3	7.5	23	0.1
Total	**3 598**		**23 600**	**100.0**

Table 4.2 Potential gross margin earnings from expanded crop areas using the current distribution of horticultural crops in the Warren–Donnelly catchments

Crop	Proportion based on current water use by crop (%)	New water resources per crop (ML)	New crop area (ha)	Gross margin per hectare ($)	Gross margin earnings from new cropping areas ($)
Potatoes	40.6	2 436	375	12 440	4 661 936
Avocados	35.6	2 136	214	50 274	10 736 708
Vegetables	11.7	699	127	5 444	692 048
Pome fruit	8.4	503	84	44 453	3 729 610
Strawberries	1.6	97	10	32 371	312 743
Wine grapes	1.7	102	102	7 450	37 882
Stone fruit	0.3	17	3	15 000	41 950
Sweet corn	0.1	6	1	10 805	146 511
Total	**100.0**	**6 000**	**916**		**20 359 391**

Sweet corn was removed from scenarios 2 and 3 because of the difficulty of developing a 12-month supply for an export market using only production from the Warren–Donnelly catchments.

4.2 Scenario 2

Six gigalitres (6000ML) of additional water is made available for new crop production. The water is allocated to the six identified products with most potential for growth. Each industry has access to 1GL (1000ML) of water. Water use figures were derived from the Irrigation Calculator (DAFWA 2014b). These water use figures take into account a high demand year and use an irrigation factor of 1.1.

The highest gross margin generator for an individual crop in this scenario is the apple industry. Apples have a low water use per hectare, which means more area of land can be planted for the same water allocation. Since the apple gross margin per hectare is close to the high value of avocado and blueberry, the apple industry can generate the highest gross margin per industry (Table 4.3).

The total gross margin earnings for all the new crops in this scenario are $24.8 million per year, which is a greater amount than Scenario 1 mainly because of the larger expansion of the apple industry.

Table 4.3 Estimated water use for the selected crops, the new planted area of crops and the total gross margin generated from new plantings for each industry

Crop	Proportion based on suggested water use by crop (%)	New water resources per crop (ML)	New crop area (ha)	Gross margin per hectare ($)	Gross margin earnings from new cropping areas ($)
Avocados	16.7	1 000	100	50 274	5 028 405
Strawberries	16.7	1 000	100	32 371	3 237 747
Apples	16.7	1 000	167	44 453	7 410 315
Blueberries	16.7	1 000	100	58 035	5 804 661
Seed potatoes	16.7	1 000	154	12 440	1 914 229
Broccoli	16.7	1 000	181	5 444	989 818
Total	**100.0**	**6 000**	**754**		**24 385 176**

4.3 Scenario 3

There is 6GL of new water available for crop production. The water is allocated to the industries that have the highest potential in terms of market expansion. To identify these products, reports focusing on the export potential of the six selected crops were reviewed. The findings from the review were discussed extensively with DAFWA development officers and industry leaders in the Warren–Donnelly catchments. From these discussions, the level of expansion for each industry was estimated.

In this scenario, the highest gross margin generator is the avocado industry. This industry receives the highest water allocation, which allows for more hectares of crop to be planted. Its gross margin per hectare ($50 274) is the second highest of all the crops in the scenario (Table 4.4).

The total gross margin earnings for all of the new crops in this scenario are $27.6 million per year. These earnings are significantly larger than scenarios 1 and 2, mainly because of the larger expansion in the pome fruit and avocado industries plus the blueberry industry.

Table 4.4 Estimated water use for the selected crops, the new crop area and the total gross margin generated from new plantings for each industry

Crop	Proportion based on suggested water use by crop (%)	New water resources per crop (ML)	New crop area planted (ha)	Gross margin per hectare ($)	Gross margin earnings from new cropping areas (A$)
Avocados	35	2 100	210.0	50 274	10 557 540
Apples	20	1 200	200.0	44 453	8 890 600
Seed potatoes	20	1 200	184.6	12 440	2 296 615
Strawberries	10	600	60.0	32 371	1 942 260
Blueberries	10	600	60.0	58 035	3 482 100
Broccoli	5	300	40.0	5 444	296 945
Total	**100**	**6 000**	**754.6**		**27 466 061**

4.4 Benefit cost ratio

A total income of between $20.4 million and $27.6 million could be added to the economy of south-west every year if 6GL of additional water is allocated for irrigated agriculture.

A benefit cost ratio and net present value analysis were calculated over a 20-year period for the three scenarios. The analysis assumed:

- three discount rates of 5%, 6% and 7%
- the cost of construction of dams and integrated pipelines for 6GL of water is $40 million
- only 6GL of additional water is made available.

Using a discount rate of 6% (the modal value), the estimated benefit cost ratio for Scenario 2 is 7:1, with an average value of 6.8:1. In other words, for every $1 of investment an additional $7 of income could be generated over the 20-year life of the project. The benefit cost ratio ranges between 5.1 and 8.5. Therefore, this project potentially provides an excellent return on investment (Table 4.5).

Table 4.5 Sensitivity analysis of the three scenarios in terms of net present value and the benefit cost ratio for investment in the irrigation schemes

Scenario	Net present value ($m)			Benefit cost ratio		
	5%	6%	7%	5%	6%	7%
1	240	221	204	6.0	5.5	5.1
2	309	284	263	7.7	7.1	6.6
3	339	312	288	8.5	7.8	7.2

5 Conclusion

The findings from a review of reports focusing on the export potential of six selected crops were extensively discussed with DAFWA development officers and industry leaders in the Warren–Donnelly catchments. These crops have export opportunities in the growing Asian market and there are some opportunities to displace interstate imports.

If an additional 6GL of new water resources is developed, it is estimated a total of between $20.4 million and $27.6 million could be added to the economy of south-west every year.

Shortened forms

Unit	Description
GL	gigalitre (1000ML)
ha	hectare
kg	kilogram
ML	megalitre
t	tonne

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