

Industry-specific impact assessment program: Citrus

Impact assessment report for project *Citrus quality standards (Stage 3)* (CT15013)

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Executive Summary

What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *CT15013: Citrus Quality Standards (Stage 3)*. The project was funded by Hort Innovation over the years ending June 2016 to June 2019.

Methodology

The investment was first analysed qualitatively within a logical framework that included activities and outputs, outcomes and impacts. Actual and/or potential impacts then were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation in monetary terms (quantitative assessment). Past and future cash flows were expressed in 2019/20 dollar terms and were discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria and a 5% reinvestment rate to estimate the modified internal rate of return (MIRR).

Results/key findings

The investment in this quality standards project addressed the delivery of good tasting citrus fruit by engaging participants across the supply chain from pre-harvest activities through to retail activity. This has been achieved by defining consumer tastes and attempting to deliver such through improved management of citrus harvesting.

The investment in CT15013 is likely to contribute to improved management of quality in line with consumer preferences, resulting in increased product sweetness and juiciness.

Investment Criteria

Total funding from all sources for the project was \$0.83 million (present value terms). The investment produced estimated total expected benefits of \$2.66 million (present value terms). This gave a net present value of \$1.83 million, an estimated benefit-cost ratio of 3.20 to 1, an internal rate of return of 15.3% and a modified internal rate of return of 10.1%.

As two of the identified impacts were not valued, the investment criteria estimated by the evaluation may have somewhat underestimated the actual performance of the investment.

Conclusions

The investment in CT15013 has contributed to improved quality of citrus products presented to Australian fresh citrus consumers. This impact is expected to maintain or increase farm gate prices of citrus products due to increased consumer satisfaction and associated increased demand for Australian citrus. This impact will result in profit increases for citrus growers and their regional supply chains. These potential impacts were valued using conservative assumptions. However, some of the assumptions on which the valuations are based are not overly well supported by evidence, hence a number of risk factors are associated with a number of assumptions used in the valuation.

Keywords

Impact assessment, cost-benefit analysis, citrus industry, citrus quality, quality standards

Introduction

Horticulture Innovation Australia Limited (Hort Innovation) required a series of impact assessments to be carried out annually on a number of investments in the Hort Innovation research, development and extension (RD&E) portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation’s current Strategic Plan and the Evaluation Framework associated with Hort Innovation’s Statutory Funding Agreement with the Commonwealth Government.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

Under impact assessment program MT18011, the first series of impact assessments were conducted in 2019 and included 15 randomly selected Hort Innovation RD&E investments (projects). The second series of impact assessments (current series), undertaken in 2020, also included 15 randomly selected projects worth a total of approximately \$7.11 million (nominal Hort Innovation investment). The second series of projects were selected from an overall population of 85 Hort Innovation investments worth an estimated \$44.64 million (nominal Hort Innovation investment) where a final deliverable had been submitted in the 2018/19 financial year.

The 15 investments were selected through a stratified, random sampling process such that investments chosen represented at least 10% of the total Hort Innovation RD&E investment in the overall population (in nominal terms) and was representative of the Hort Innovation investment across six, pre-defined project size classes.

Under a separate impact assessment program (MT19012), a second series of impact assessments addressed a requirement for industry-specific ex-post independent impact assessments of the almond (AL), banana (BA), citrus (CT) and onion (VN) RD&E investment funds.

Twenty-nine RD&E investments (projects) were selected through a stratified, random sampling process. The industry samples were as follows:

- Nine AL projects were chosen worth \$5.84 million (nominal Hort Innovation investment) from an overall population of 21 projects worth an estimated \$10.78 million,
- Eight BA projects worth \$3.02 million (nominal Hort Innovation investment) from an overall population of 24 projects worth approximately \$16.72 million,
- Eight CT projects worth \$5.40 million (nominal Hort Innovation investment) from a total population of 35 projects worth \$15.78 million, and
- Four VN projects worth \$2.40 million (nominal Hort Innovation investment) from an overall population of 8 projects worth \$3.89 million.

The project population for each industry included projects where a final deliverable had been submitted in the five-year period from 1 July 2014 to 30 June 2019. The projects for each industry sample were chosen such that the investments represented (1) at least 10% of the total Hort Innovation RD&E investment expenditure for each industry, and (2) the SIP outcomes (proportionally) for each industry.

Four projects had been randomly selected as part of a related Hort Innovation project (MT18011) and were included in the samples for the AL industry (AL14006 and AL16004) and the CT industry (CT15006 and CT15013). This left 25 unique projects randomly selected for evaluation under MT19012.

Project CT15013: *Citrus Quality Standards (Stage 3)* was randomly selected as one of the 15 investments under MT18011 and also was randomly selected as one of the investments under MT19012 and was analysed in this report.

General Method

The impact assessment follows general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres, State Departments of Agriculture, and some universities. The approach includes both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, outcomes, and actual and/or potential impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. Where impact valuation was exercised, the impact assessment used cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background & Rationale

The Australian citrus industry is one of Australia’s ‘traditional’ horticultural industries. A range of citrus types are produced in Australia. Oranges are the predominant citrus type grown by tonnage followed by mandarin, lemon/lime and grapefruit, in that order. Table 1 below illustrates some recent descriptive statistics for the Australian citrus industry.

Table 1: Australian Citrus Production and Value for Years Ending June 2017 to 2019

Year ended June	Total Australian Production (tonnes)	Fresh Supply (tonnes)	Fresh Imports (tonnes)	Fresh Australian Supply (tonnes)	Fresh Supply Wholesale Value (m\$)	Fresh Supply Wholesale Value (\$/tonne)
2017	714,740	309,822	34,061	275,761	572.2	1,847
2018	747,032	294,956	27,749	267,207	534.7	1,813
2019	744,354	294,568	24,760	269,808	539.0	1,830
Average	735,375	299,782	28,857	270,925	548.6	1,830

Source: Australian Horticultural Statistics Handbook, 2018/19

The research and development activities of the citrus industry are guided by the industry’s Strategic Investment Plan (SIP). The activities are funded by levies payable on citrus produced in Australia.

The process of preparing the latest SIP was managed by Hort Innovation in consultation with the Industry Representative Body (Citrus Australia) and the Strategic Investment Advisory Panel. The current citrus SIP has been driven by levy payers and addresses the Australian citrus industry’s research and development (R&D) needs (and marketing specifically for the orange industry) from 2017 to 2021.

The Australian Citrus Quality Standards Program (ACQS) commenced in 2011 and has delivered significant fruit quality improvements along the citrus supply chains since that time. Project investments by ACQS that preceded CT 15013 (Stage 3) included Stage 1 (Hort Innovation Project CT09055) and Stage 2 (Hort Innovation Project CT12004). These early stage investments increased industry awareness of the importance of quality standards and led to sensory research into consumer preferences and associated maturity levels. This associated research developed a new maturity measure called the Australian Citrus Quality Standard. This was the first citrus maturity standard developed in Australia that was based on consumer preferences.

As a result of this objectively-determined linkage, interest by the citrus industry in fruit maturity and fruit flavour heightened and led to the development of a targeted research program to improve citrus taste (Stage 3 of ACQS, that is, the current Project CT15013).

Project Details

Summary

Project Code: CT15013
 Title: *Citrus Quality Standards (Stage 3)*
 Research Organisation: Citrus Australia
 Project Leader: Nathan Hancock, Citrus Australia
 Period of Funding: September 2015 to October 2018

Objectives

The broad aim of the ACQS is to ensure the price of Australian citrus is maximised by improving the industry’s reputation as a reliable supplier of high quality citrus, capitalising on aspects of taste, colour, freshness and food safety. Given this broad aim, and the two preceding stages to the Citrus Quality Standards investment, the specific objectives of Project CT15013 (Stage 3) were:

- 1) To maintain the current ACQS market testing and reporting program,
- 2) To develop and deliver a maximum granulation standard for Imperial mandarin,
- 3) To liaise with the supply chain on Australian Citrus Quality Standards,
- 4) To develop and implement a Standard Operating Procedure for start of harvest,
- 5) To develop an ACQS pre-harvest field testing program and reporting protocol,
- 6) To foster an environment for research collaboration and national extension of R&D outcomes.

Logical Framework

Table 2 following provides a detailed description of the project in a logical framework format.

Table 2: Logical Framework for Project CT15013 (Stage 3)

Activities	<p>February 2016 to December 2016</p> <ul style="list-style-type: none"> • A Domestic Leadership Group (including a mix of vertically integrated citrus businesses) was formed to oversee the project; meetings were held twice annually. • Market testing and reporting processes were developed, and arrangements made with contractors to test fruit in three major cities (Brisbane, Sydney and Melbourne). • A new ACQS report format was developed that incorporated Imperial mandarin granulation in the context of quality assurance. • Project team meetings were held with a number of retail Produce Quality Managers. • A visual guide for assessing Imperial mandarin granulation was developed. • Liaison with growers first took place in Queensland (QLD) to sample fruit from orchards that represented a range of citrus tree ages across varieties common to the region. • A meeting with the QLD Regional Advisory Committee was held as a part of stakeholder consultations; regional advisory groups and committees were established in all citrus regions including Murray Valley, Riverina, Central Burnett, South Australia and Western Australia. • Contractors were trained to assess granulation. • Sampling techniques and protocols for harvesting fruit were developed. • Quality assurance staff at retail outlets were trained and any additional contractors trained as required. • Pre-harvest field testing was carried out in QLD and associated reporting effected to stakeholders of the results of the pre-harvest maturity testing.
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- Market testing of fruit maturity was carried out in Brisbane, Melbourne and Sydney and weekly results reported.
- The weekly assessment of granulation in Imperial mandarin took place at the Brisbane market.
- A network of field test sites in the Riverland was developed.
- Field testing of navels in the Riverland took place with associated reporting to the national industry.
- Contractors were audited against the Citrus Australia maturity testing protocols.
- A pilot program Standard Operating Procedure (SOP) for start of harvest was prepared.
- Various communication and consultation activities were carried out by the project including regional forums, interaction with growers and associated industry committees as well as engagement with marketers and retailers.

February 2017 to December 2017

- Continuing consultations took place with industry groups on quality issues.
- Regular meetings were held with retail produce quality managers.
- Further meetings occurred with contractors regarding market testing and updating the reporting spreadsheet.
- The visual guide to assist with assessing Imperial mandarin granulation was applied.
- As in 2016, pre-season quality field testing was carried out in QLD in the various citrus growing areas.
- Another meeting with the QLD Regional Advisory Committee was held.
- Following the early Queensland activity, similar activities were carried out in locations in the southern States.
- Discussions with marketers and retailers continued as in 2016.
- As in the previous year, market testing of fruit maturity commenced in Brisbane and continued in Sydney and Melbourne.
- In March/April of 2017 a national weekly report of maturity test results commenced.
- The existing Pass to Pick SOP was extended and a pilot program commenced.
- A community of practice teleconference was held to discuss R&D progress and seasonal observations.
- Various communication and consultation activities continued in 2017 including interaction with growers and associated industry committees as well as with marketers and retailers.
- Apart from project reports, a range of communication articles about the progress of the project were produced to inform a wider industry audience.

February 2018 to December 2018

- Further consultations on quality issues took place with industry groups.
- A series of meetings were held regularly with retail produce quality managers.
- Further meetings occurred with Rudge Produce (contractors) regarding market testing and other issues.
- Assessment of granulation of Imperial mandarin continued.
- Pre-season quality field testing was carried out in QLD in the various citrus growing areas.
- Progress on quality standards was discussed with the QLD Regional Advisory Committee.
- Visits to wholesale markets were made to observe and discuss quality issues with marketers.
- Following the early Queensland activity, similar activities were carried out in locations in the southern States where a network of field test sites was developed and field testing of navels was carried out.
- Regular market visits took place and discussions with marketers and retailers continued.

	<ul style="list-style-type: none"> • Market testing of fruit maturity commenced in Brisbane and continued in Sydney and Melbourne markets. • The national weekly report of maturity test results continued. • The pilot program SOP continued. • A further community of practice teleconference was held to discuss research and development (R&D) progress and seasonal observations. • Various communication and consultation activities continued in 2018 including interaction with growers and associated industry committees as well as with marketers and retailers. • The Domestic Leadership Group held a post-season meeting. • Apart from producing various project reports, a range of communication articles about the progress of the project were produced to inform a wider industry audience.
Outputs	<ul style="list-style-type: none"> • The maintenance of the existing ACQS market testing and reporting program was continued and enhanced as the understanding of consumer preferences improved with the project. For example, juice content was removed as a maturity indicator as it had poor correlation with consumer acceptability; also, a maximum granulations standard was added as a result of a sensory evaluation study. • The fruit sampling method was changed in 2017 to take measurements from each fruit in a ten fruit sample, rather than from an aggregate ten fruit sample. • A maximum granulation standard for Imperial mandarin was developed and tested. • The project built upon the legacy of previous quality projects by heavily engaging supply chain participants including citrus growers, packers, researchers, regulators agronomists, retailers and wholesalers. • The project developed a SOP for start of harvest to ensure that unacceptable fruit is not harvested. The standard operating procedure was finalised in 2018. • The pre-harvest testing and reporting process supplied objective evidence of fruit quality, as opposed to industry relying on historical data to predict maturity at harvest.
Outcomes	<ul style="list-style-type: none"> • An increased level of awareness, knowledge and understanding by citrus supply chain participants of consumer preferences and expectations regarding quality. • An improved level of citrus quality being offered to citrus consumers. • Imperial mandarin with reduced or no granulation being offered to mandarin consumers. • Growers and supply chain groups will incur minimal expenses adopting and performing the pre-harvest standard operating procedures as the majority of the equipment and skills required is only an extension of what sampling and testing was already occurring (Mara Milner, pers. comm., 2020). • Citrus Australia also assisted industry with the transition by holding information sessions at national and regional events as well as one on one training sessions in growing and testing regions. Citrus Australia also published detailed free to use written procedures and guides including worksheets that calculated results as a resource. • The sampling and testing procedure to assess for granulation in an Imperial mandarin is best performed on fruit taken from the orchard before it is harvested. If a patch or orchard of fruit is assessed and found to be severely granulated a decision to delay harvest should be made. • Imperial mandarins are only sold on the domestic market as they do not have a long enough shelf life to be exported so the majority is sold throughout the supermarket chain stores. • The chains adopted the granulation standard and testing procedure and test all Imperial mandarin consignments on arrival. Fruit that is deemed granulated is rejected and fruit that passes is offered for sale. Fruit that meets the standard is not necessarily sold at a higher price, it is the rejected fruit that ends up being an expense to growers and packers (Mara Milner, pers. comm., 2020).

	<ul style="list-style-type: none"> • Citrus Australia’s Standard SOP for the start of harvest was designed and developed to educate growers and the supply chain on the importance of thorough testing of fruit in the orchard prior to harvest so that it meets the ACQS. The fate of fruit not achieving the ACQS limits for acceptable eating quality is best managed in the orchard and the fruit not harvested until it is ready. • If citrus fruit is harvested and does not meet the ACQS limits it is challenging for a packer to handle as any future market/s have specification limits of acceptability. Fruit can be offered for sale to the domestic and export market but has the potential to impair prices and the reputation of good quality fruit. It can be processed into juice but this is usually at a higher cost because sugars need to be added to make up for the shortfall. Fruit can also be sent for feed or dumped. Any of the options for fruit not meeting the ACQS limits result in very little to nil return to the grower which makes it unviable to sustain their orchards (Mara Milner, pers. comm., 2020).
Impacts	<ul style="list-style-type: none"> • Increased consumer satisfaction with fresh citrus in the Australian market place due to increased sweetness and flavour that better reflects Australian consumer preferences, resulting in more consistent demand and increased consumption. • Potential maintenance of, or increase in, price for the existing level of Australian fresh citrus consumption. • Some regional social impacts may have been derived from increased spill-overs to families and businesses in citrus growing regions from increased grower and supply chain profitability increases. • An increase in industry cohesiveness along the citrus value chain. • By ensuring fruit harvested meets the ACQA, growers are not faced with disposal costs or selling product for animal feed or processing into juice by adding sugar; all of these options result in very low or nil net returns to growers (Mara Milner, pers. comm., 2020)

Project Investment

Nominal Investment

Table 3 shows the annual investment made in Project CT15013 (Stage 3) by Hort Innovation. There was no in-kind financial contribution from Citrus Australia (Mara Milner, pers. comm., 2020).

Table 3: Annual Investment in Project CT15013 (nominal \$)

Year ended 30 June	Hort Innovation (\$)	Citrus Australia (\$)	TOTAL (\$)
2016	117,951	0	117,951
2017	197,112	0	197,112
2018	158,327	0	158,327
2019	119,013	0	119,013
Totals	592,403	0	592,403

Source: Project Research Agreement

Program Management Costs

For the Hort Innovation investment the cost of managing and administration of funding was added to the Hort Innovation contribution for the project via a management cost multiplier (1.162). This multiplier was estimated based on the share of ‘payments to suppliers and employees’ in total Hort Innovation expenditure (3-year average) reported in the Hort Innovation’s Statement of Cash Flows (Hort Innovation Annual Report, various years). This multiplier was then applied to the nominal investment by Hort Innovation shown in Table 3.

Real Investment and Extension Costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2020). No additional costs of extension were included as the project itself heavily involved the industry and was industry oriented; the project also maintained strong communication channels along the citrus supply chains as these were integral to the project success.

Impacts

Table 4 provides a summary of the principal types of impacts delivered by the project, based on the logical framework. Impacts have been categorised into economic, environmental and social impacts.

Table 4: Triple Bottom Line Categories of Principal Impacts from Project CT15013

Economic	<ul style="list-style-type: none"> • A potential increase in consumption of citrus driven by a reduced frequency of negative experiences. • A potential increase in farm gate value of a proportion of fresh citrus production in Australia, driven by quality improvements as ascertained by domestic fresh citrus consumers, and the associated increase in consumption.
Environmental	<ul style="list-style-type: none"> • Reduced need for waste disposal affecting the environment
Social	<ul style="list-style-type: none"> • Some regional social impacts may have been derived from increased spill-overs to families and businesses in citrus growing regions from increased grower and supply chain profitability increases. • An increase in industry cohesiveness along the citrus value chain.

Public versus Private Impacts

The impacts identified from the investment are predominantly private impacts accruing to citrus growers and their supply chains in most Australian citrus producing regions in Australia. However, some minor public benefits may have been produced in the form of spill-overs to regional communities from enhanced grower incomes, and increased supply chain value aligned with the increased value of fresh citrus production.

Distribution of Private Impacts

The private impacts will have been distributed along the citrus supply chains. The share of impact realised by supply chain participants will depend on both short- and long-term supply and demand elasticities that are experienced along the various linkages in the supply chains.

Impacts on Other Australian Industries

It is likely that most impacts will be confined to the Australian citrus industry. However, it should be noted that other Australian industries have acknowledged and admired the uniform quality standards Citrus Australia has produced and implemented and have looked into implementing an ACQS type standard for their commodities (Mara Milner, pers. comm., 2020).

Impacts Overseas

It is likely that most impacts will be confined to Australia. However, as a significant proportion of Australian fresh citrus production is exported, there may well be some spill-overs to increased overseas consumer satisfaction resulting from the project.

Match with National Priorities

The Australian Government’s Science and Research Priorities and Rural RD&E priorities are reproduced in Table 5. The project outcomes and related impacts will contribute primarily to Rural RD&E Priority 1 and 4, and to Science and Research Priority 1.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	Science and Research Priorities (est. 2015)
<ol style="list-style-type: none"> 1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D 	<ol style="list-style-type: none"> 1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

Sources: DAWR (2015) and OCS (2016)

Alignment with the Citrus Strategic Investment Plan 2017-2021

The strategic outcomes and strategies of the Australian citrus industry are outlined in the Citrus Strategic Investment Plan 2017-2021¹ (Hort Innovation, 2017). Project CT15013 is directly relevant to a number of the desired outcomes in the SIP. First the project directly addresses the third desired outcome: “Improved product quality and increased productivity from the application of innovation”. This outcome is directly addressed through the strategy 3.2: undertaking R&D and extension to enhance product quality such as flavour and juiciness.

The project addresses also outcome 4 via strategies 4.1 and 4.2 to build the skills, capacity and knowledge of growers and other members of the citrus value chain. Also, outcome 1 (an increased demand for citrus) is addressed via strategies 1.2 and 1.3.

Valuation of Impacts

Impacts Valued

The impact that was valued was the increased value Australian consumers would pay for delivery of citrus fruit with improved flavour and sweetness. Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. The impact of increased regional community spill-overs was not valued largely due to the difficulty in developing credible assumptions. Further, the increase in industry cohesiveness along the citrus value chain was not specifically valued itself, but could be viewed as being a component of delivering the improved quality of fruit.

Summary of Assumptions

The impact that was valued (the increased value Australian consumers would pay for delivery of citrus fruit with improved flavour and sweetness) was valued via the increased wholesale price of citrus produced as influenced by the Citrus Quality Program.

The assumptions that have been developed to value increases in citrus quality desired by consumers are provided in Table 6. The assumption table shows a small proportion of citrus fruit are estimated to have been the source of improvements due to the new protocols developed by the industry. The price improvement increase is conservative and it has been assumed that there will be limited additional costs associated with capturing the quality improvement.

¹ For further information, see: <https://www.horticulture.com.au/hort-innovation/funding-consultation-and-investing/investment-documents/strategic-investment-plans/>

Table 6: Summary of Assumptions for Impact Valued

Variable	Assumption	Source/Comment
Impact 1: Value of increase in value of fresh citrus quality on the Australian market		
Australian fresh citrus production sold on domestic market	270,925 tonnes per annum (excludes fresh imports, exports and juicing product)	Three year average over 2017, 2018 and 2019 (Horticultural Statistics Handbook, 2018/19)
Fresh wholesale value	1830.0 per tonne	
Proportion of fresh production sold as fruit where quality increases will occur	20%	Estimate by Analyst
Price increase due to quality impact	1.5%	
Gross value gain	\$1.487 m per annum	270,925 x \$1830 x 20% x 1.5%
Additional annual costs to growers to meet the ACQS standards	\$0	Estimate by Analyst, based on discussions with Mara Milner, Citrus Australia
Net income gain to growers	\$1.487 m per annum	\$1.487 m - \$0 m
First year of some impact from Stage 3 project (year ended June)	2020	Estimate by Analyst
Years to maximum adoption	5	
Year of maximum adoption	2024	
Risk and attribution factors		
Probability of impact (proportion of fresh citrus fruit impacts)	75%	Estimate by Analyst
Probability of impact (value increase)	75%	
Attribution to Stage 3 of Project	22.3%	Based on Stage 3 project costs as % Total Stages 1, 2, and 3 investment

Results

All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of investment (2018/19) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Tables 7 and 8 show the investment criteria estimated for different periods of benefits for the total investment and the Hort Innovation investment alone. As Hort Innovation was the only investor in the project, the investment criteria are the same for both tables.

Table 7: Investment Criteria for Total Investment in Project CT15013

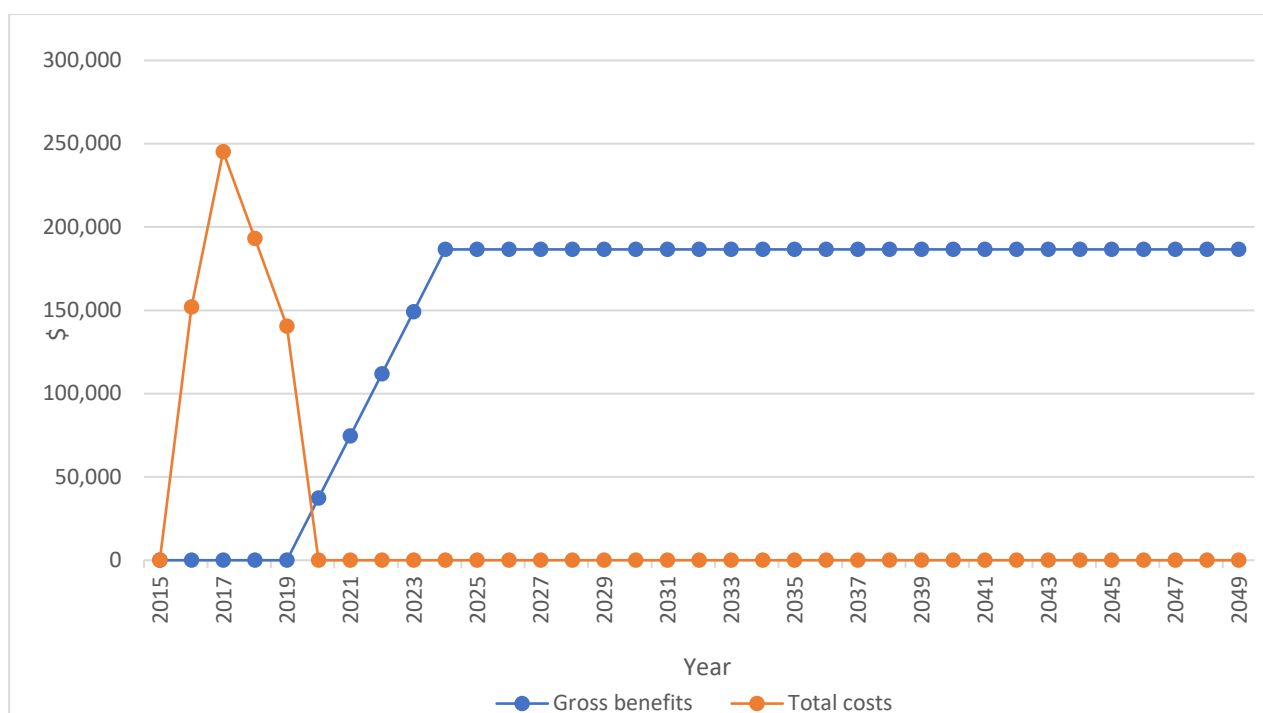
Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits (\$m)	0.00	0.49	1.16	1.68	2.09	2.41	2.66
Present Value of Costs (\$m)	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Net Present Value (\$m)	-0.83	-0.34	0.33	0.85	1.26	1.58	1.83
Benefit-Cost Ratio	0.00	0.59	1.40	2.02	2.51	2.90	3.20
Internal Rate of Return (%)	negative	negative	9.73	13.28	14.53	15.03	15.26
MIRR (%)	negative	negative	10.06	11.66	11.31	10.68	10.09

Table 8: Investment Criteria for Hort Innovation Investment in Project CT15013

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits (\$m)	0.00	0.49	1.16	1.68	2.09	2.41	2.66
Present Value of Costs (\$m)	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Net Present Value (\$m)	-0.83	-0.34	0.33	0.85	1.26	1.58	1.83
Benefit-Cost Ratio	0.00	0.59	1.40	2.02	2.51	2.90	3.20
Internal Rate of Return (%)	negative	negative	9.73	13.28	14.53	15.03	15.26
MIRR (%)	negative	negative	10.06	11.66	11.31	10.68	10.09

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the CT15013 investment plus 30 years from the last year of investment are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs



Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 9 presents the results that show a moderately high sensitivity to the discount rate.

Table 9: Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5%	10%
Present Value of Benefits (\$m)	5.22	2.66	1.59
Present Value of Costs (\$m)	0.73	0.83	0.94
Net Present Value (\$m)	4.49	1.83	0.66
Benefit-cost ratio	7.15	3.20	1.70

A sensitivity analysis was then undertaken for the proportion of fresh fruit that are assumed to receive a value increase. Results are provided in Table 10.

Table 10: Sensitivity to Assumption of Proportion of Fresh Fruit Assumed to Capture a Value Increase (Total investment, 30 years)

Investment Criteria	Proportion of Citrus Receiving a Value Increase		
	10%	20% (Base)	30%
Present Value of Benefits (\$m)	1.33	2.66	3.98
Present Value of Costs (\$m)	0.83	0.83	0.83
Net Present Value (\$m)	0.50	1.83	3.15
Benefit-cost ratio	1.60	3.20	4.80

A sensitivity analysis was then undertaken for the average value increase assumed for the proportion of fresh fruit that are assumed to receive the value increase. Results are provided in Table 11.

Table 11: Sensitivity to Fresh Fruit Value Increase Assumption (Total investment, 30 years)

Investment Criteria	Value Increase		
	1%	1.5% (Base)	2%
Present Value of Benefits (\$m)	1.77	2.66	3.54
Present Value of Costs (\$m)	0.83	0.83	0.83
Net Present Value (\$m)	0.94	1.83	2.71
Benefit-cost ratio	2.13	3.20	4.27

Confidence Rating

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes. A confidence rating based on these two factors has been given to the results of the investment analysis (Table 12). The rating categories used are High, Medium and Low, where:

- High: denotes a good coverage of benefits or reasonable confidence in the assumptions made
- Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
- Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
High	Low

Coverage of benefits was assessed as High. The most important impact from the investment was valued. The impacts relating to increased regional community spill-overs was not valued. Consequently, the investment criteria as provided by the valued benefits are likely to be only marginally underestimated.

Confidence in assumptions for valuation was rated as Low-Medium as many of the assumptions made were not supported by surveys or other forms of evidence and had to be made according to the limited evidence produced by the project.

Conclusion

The investment in CT15013 is likely to contribute to improved management of quality in line with consumer preferences, resulting in product sweetness and juiciness.

Total funding from all sources for the project was \$0.83 million (present value terms). The investment produced estimated total expected benefits of \$2.66 million (present value terms). This gave a net present value of \$1.83 million, an estimated benefit-cost ratio of 3.20 to 1, an internal rate of return of 15.3% and a modified internal rate of return of 10.1%.

Glossary of Economic Terms

Cost-benefit analysis:	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Benefit-cost ratio:	The ratio of the present value of investment benefits to the present value of investment costs.
Discounting:	The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
Internal rate of return:	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits = present value of costs.
Investment criteria:	Measures of the economic worth of an investment such as Net Present Value, Benefit-Cost Ratio, and Internal Rate of Return.
Modified internal rate of return:	The internal rate of return of an investment that is modified so that the cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate).
Net present value:	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Present value of benefits:	The discounted value of benefits.
Present value of costs:	The discounted value of investment costs.

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Abbreviations

ACQS	Australian Citrus Quality Standards
CRRDC	Council of Research and Development Corporations
DAWR	Department of Agriculture and Water Resources (Australian Government)
MIRR	Modified Internal Rate of Return
OCS	Office of Chief Scientist, Canberra
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
SIP	Strategic Investment Plan
SOP	Standard Operating Procedure