Hort Innovation

Industry-specific impact assessment program: Almond

Impact assessment report for project *Food safety in almonds – Stage 2* (AL11009)

Impact analyst:

Michael Clarke

Delivery partner:

AgEconPlus and Agtrans Research

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *VG11009: Food Safety in Almonds – Stage 2.* The project was funded by Hort Innovation over the period September 2011 to August 2016.

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

Investment in this research project has provided almond growers and supply chain partners with solutions to the challenge of aflatoxin contamination from *Aspergillus* spp. fungus. Aflatoxin contamination has the potential to be a major industry challenge that would limit future almond industry growth and profit. Implementation of project findings will also deliver additional confidence in the safety of Australian almonds.

Investment Criteria

Total funding from all sources for the project was $3.67 million (present value terms). The investment produced estimated total expected benefits of $16.11 million (present value terms). This gave a net present value of $12.44 million, an estimated benefit-cost ratio of 4.39 to 1, an internal rate of return of 17.9% and a modified internal rate of return of 9.9%.

Conclusions

The Hort Innovation investment in Project AL11009 has identified key contributing factors and critical control points and developed response measures to minimise *Aspergillus* spp. and aflatoxin contamination in Australian almonds. Several of the impacts identified were not valued as the impacts were considered uncertain and difficult to value with credible assumptions. Hence, investment criteria provided by the valuation may be underestimates of the actual performance of the investment.

Keywords

Impact assessment, cost-benefit analysis, almond, food safety.

Introduction

All research, development, and extension (RD&E) and marketing levy investments undertaken by Horticulture Innovation Australia Limited (Hort Innovation) are guided and aligned to specific investment outcomes, defined through a Strategic Investment Plan (SIP). The SIP guides investment of the levy to achieve each industry's vision. The current industry SIPs apply for the financial years 2016/17 – 2020/21.

In accordance with the Organisational Evaluation Framework, Hort innovation has the obligation to evaluate the performance of its investment undertaken on behalf of industry.

This impact assessment program addresses this requirement through conducting a series of 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 22 projects worth approximately $16.72 million,
- Eight CT projects worth $5.4 million (nominal Hort Innovation investment) from a total population of 35 projects worth $15.78 million, and
- Four VN projects worth $2.4 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.

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 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 uses 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

Background

The Australian almond industry is a significant horticultural sector with a five-year estimated production value of $701 million and a production volume of 85,909 tonnes kernel weight equivalent – Table 1.

Table 1: Almond Industry Performance 2015-2019

Year Ended 30 June	Production (t)	Gross Value of Production ($m)	Export Volume (t)	Export Value ($m)	Unit Value of Exports ($/t)	Export to EU (t)
2015	82,509	707.5	58,351	521.8	8,942	22,759
2016	82,333	854.1	60,633	616.2	10,163	23,563
2017	80,800	553.6	66,311	461.2	6,955	24,482
2018	79,901	553.1	64,196	440.3	6,859	18,479
2019	104,000	835.1	86,451	675.0	7,808	13,427
Average	85,909	701.0	67,188	543.0	8,080	20,542

Source: Australian Horticulture Statistics Handbook and Almond Insights, various years. Tonnes is kernel weight equivalent

Almonds are Australia's most valuable horticultural export crop accounting for 20% of the value of fresh horticulture exports and generating a five-year export value of $543 million or approximately $8,000/tonne. An average of 20,542 tonnes of Australian almonds are exported to the European Union (EU). Almonds are grown in the south of Australia, with the majority of production occurring along the Murray River. Key production areas include the North Adelaide Plains (South Australia), Riverland (South Australia), Sunraysia (Victoria) and the Riverina (NSW). Together these four areas account for 97% of production.

Australia's almond growing season commences with the almond blossom in July and August each year. Harvest takes place in February and March, with produce ready for the market in April and May. Over 90% of almonds consumed in Australia are grown and produced by Australian farmers.

Almond research and development (R&D) activity is guided by the Almond industry's Strategic Investment Plan (SIP). The activities are funded by levies payable on almonds produced in Australia; and the R&D levy funds are managed by Hort Innovation.

The current SIP has been developed with levy payers and addresses the Australian Almond industry's needs from 2017 to 2021. Strategies and priorities in the Plan have been driven by a set of five desired outcomes (Hort Innovation, 2017):

1. Pest and disease damage to almonds has been reduced through enhanced integrated pest management and integrated disease management.
2. A major productivity gain in almond pollination by 2022 through a 25% reduction in honey bee stocking rate with no loss in pollination efficiency (nut set).
3. Improvements in the crop production system have lifted average industry kernel yield from 3 to 4 t/ha, 4ML of irrigation water generates a tonne of almond kernel yield and proven 'shake and catch' harvesting / processing technology is in place.
4. Australian almonds are an informed industry that adopts R&D outcomes and has the capacity to support current and future industry needs.
5. Increased domestic almond consumption up from 16,000 t in 2016 to 27,500 t in 2022. Increased export sales up from 61,000 t in 2016 to 110,000 t in 2022.

Rationale

A major industry challenge that would limit future almond industry growth and profit is the failure of Australian almond exports to meet stringent aflatoxin thresholds imposed by the EU. The EU allows aflatoxin levels of up to 10 parts per billion (ppb), by way of contrast the United States allows aflatoxin levels of up to 20 ppb. In 2018/19 the EU accounted for 22% of Australia's almond exports. Significant costs are incurred by the almond industry if export consignments are rejected by the EU.

Aflatoxins are carcinogenic and of serious concern to human and animal health (almond hulls and other by products are used as stock feed). Aflatoxins are produced by a group of *Aspergillus* fungi. Hort Innovation scoping project AL09207 showed increased *Aspergillus* infection in nuts with damaged and damp kernels. AL09207 highlighted knowledge gaps with regard to the role of diseases, especially hull rot, anthracnose, and carob moth (*Ectomyelois ceratoniae*) in increasing *Aspergillus* infection. The need to define critical control points across the whole production and value chain was also identified.

The aim of this project (AL11009) was to identify key contributing factors and critical control points and develop an industry-wide strategy to minimise *Aspergillus* and aflatoxin contamination.

Project Details

Summary

Project Code: AL11009 Title: Food Safety in Almonds – Stage 2 Research Organisation: Department of Economic Development, Jobs, Transport and Resources (DEDJTR), Victoria Project Leader: S. Chin Gouk Period of Funding: September 2011 to August 2016

Objectives

Specific objectives of project AL11009 were:

1. Increase knowledge of the biology, development and spread of aflatoxin producing *Aspergillus* spp. in almond farms and the value chain.
2. Clarify the role of hull rot, anthracnose, and diseased mummies (almonds that remain on the tree) in relation to *Aspergillus* infection of nuts and kernels.
3. Develop a preliminary understanding of the phenology (life cycle) and incidence of carob moth, and define its relationship with diseased mummies, nut damage and *Aspergillus* infection.
4. Identify the critical control points across the value chain for minimising the risk of *Aspergillus* infection and aflatoxin contamination.
5. Identify the influence of pre- and post-harvest conditions and moisture levels on the development of *Aspergillus* and aflatoxin in nuts and kernels.
6. Develop integrated management strategies for diseases and pests associated with *Aspergillus* risks.
7. Develop management strategies for stockpiling of almonds to minimise *Aspergillus* and aflatoxin risks.

Logical Framework

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

Table 2: Logical Framework for Project AL11009

Activities	The important activities included: • Assembly of a multidisciplinary project team drawn from DEDJTR/Vic DPI and CSIRO. • Project team included expertise in mycology, plant pathology, entomology, integrated pest and disease management, almond growing, processing, and storage management. • Completion of team meetings to design field experiments, research tools and monitor project progress. • Development of protocols to monitor *Aspergillus*, carob moth and disease progression. • Culturing and identification of the *Aspergillus* spp. found in Australian almond orchards. • Completion of a literature review on chemical control options for *Aspergillus* and the fungal pathogen, *Rhizopus* spp. which is also present in Australian almond orchards. • Develop protocols for bioassay of microbial sensitivity/resistance to fungicides. • Develop and test aflatoxin detection methodology. • Installation of carob moth traps and monitoring of almond blocks. • Completion of analysis of the level of *Aspergillus*, carob moth and diseased mummies on almonds and orchard soils. • Analysis of aflatoxins in almond kernels. *Aspergillus* spp. identified and curated. Analysis of toxigenic strains of *Aspergillus* spp. completed. • Testing and installation of sensors and data loggers to monitor and record fungus levels in almond stockpiles. • In response to feedback received from peak industry body ABA, project refocussed on addressing the most significant cause of *Aspergillus* infection of almonds.

	• Analysis of data that shows lack of a link between carob moth kernel damage and *Aspergillus* infection. Drafting of a factsheet on the carob grub. • Profiling of environmental conditions and the presence of *Aspergillus* in almond stockpiles. Data indicated significant levels of *Aspergillus* present in stockpiles. • Almond stockpiles covered with PVC sheeting identified as a major cause of *Aspergillus* infestation. Contract variation negotiated to test PVC alternatives. Trials successfully completed using a waterproof and breathable alternative to PVC sheeting. • Preparation and delivery of project milestone reports, final report, scientific papers, extension materials, industry workshops, and conference presentations.
Outputs	The important outputs of the project included: • Knowledge that moisture build-up in almonds during postharvest storage encourages microbial growth, and that the standard PVC tarps used by the majority of almond growers encourage condensation build-up which increases microbial and aflatoxin risks. In addition to aflatoxin risk, losses from rots and spoilage of almonds in the field and rejection of nuts during processing also occurs. • A technical bulletin on the biology and development of *Aspergillus* in almond production and value chain, including guidelines for minimising the risks of contamination. • A technical report on the relationships of diseases and carob moth with *Aspergillus* infection, and strategies for minimising their damage. • A technical fact sheet on the seasonal phenology of carob moth. • Presentations at the Australian Almond Industry Conference to raise industry awareness of factors contributing to increased risks of *Aspergillus* and aflatoxins. • Industry workshops in key production regions to extend guidelines for minimising *Aspergillus* and aflatoxin contamination. • Twice yearly milestone reports and a final report detailing research findings, outcomes, and recommendations. • A scientific publication on ecology of *Aspergillus* in almond orchards and the value chain. • A scientific publication on *Aspergillus* biology and factors influencing production of aflatoxins in almonds.
Outcomes	The outcomes driven by the project included: • Grower understanding that carob moth does not cause *Aspergillus* infection and carcinogenic aflatoxin contamination but is responsible for kernel damage and needs to be controlled. • Uptake of grower and supply chain solutions to *Aspergillus* and a resultant reduction in aflatoxins contamination of Australian almonds. • Reduction in the rejection rate of Australian almond exports to the EU. • Safe and healthy Australian almond products for all consumers.
Impacts	• Economic – reduction in additional handling costs and value lost from Australian almond exports that fail to meet strict EU aflatoxins regulations. • Economic – reduction in losses associated with rots and spoilage when PVC stockpile covers are replaced with breathable alternatives. • Capacity – increased researcher, grower, and supply chain partner skills in understanding and managing aflatoxin risk. • Social – further reduction in the already small risk of illness associated with the consumption of Australian almonds and Australian almond products. • Social - contribution to improved regional community wellbeing from spill-over benefits as a result of a stable, profitable almond industry - North Adelaide Plains, Riverland, Sunraysia and Riverina.

Project Investment

Nominal Investment

Table 3 shows the annual investment made in Project AL11009 by Hort Innovation and in-kind contributions made by DEDJTR and the CSIRO Food & Nutrition Flagship.

Table 3: Annual Investment in Project AL11009 (nominal $)

Year ended 30 June	HORT INNOVATION ($)	DEDJTR ($)	CSIRO ($)	TOTAL ($)
2012	147,500	126,143	17,205	290,848
2013	352,300	301,289	41,094	694,683
2014	132,496	113,311	15,455	261,262
2015	200,011	171,051	23,330	394,392
2016	102,668	87,802	11,976	202,446
2017	248,186	212,250	28,950	489,386
Total	**1,183,161**	**1,011,847**	**138,010**	**2,333,018**

Source: AL11009 Executed Research Agreement and Revised Schedule

Program Management Costs

For the Hort Innovation investment the cost of managing the Hort Innovation 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 extension costs were incurred.

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 AL11009

Economic	• Reduction in additional handling costs and value lost from Australian almond exports that fail to meet strict EU aflatoxins regulations. • Reduction in losses associated with rots and spoilage when PVC stockpile covers are replaced with breathable alternatives.
Environmental	• Nil
Social	• Increased researcher, grower, and supply chain partner skills in understanding and managing aflatoxin risk. • Further reduction in the already small risk of illness associated with the consumption of Australian almonds and Australian almond products. • Contribution to improved regional community wellbeing from spill-over benefits as a result of a stable, profitable almond industry - North Adelaide Plains, Riverland, Sunraysia and Riverina.

Public versus Private Impacts

The impacts identified from the investment are predominantly private impacts accruing to almond growers and the almond supply chain. However, some public benefits have also been produced including a reduced risk of a food safety incident associated with almond consumption, capacity building and spill-over benefits to regional communities.

Distribution of Private Impacts

The private impacts will have been distributed between growers, processor/packers, wholesalers, exporters, retailers, and consumers in Australia and overseas. The share of impact realised by each link in the supply chain will depend on both short- and long-term supply and demand elasticities in the almond market.

Impacts on Other Australian Industries

Additional knowledge on *Aspergillus*, aflatoxins, insect, and other vectors as well as postharvest storage will be of value to other horticultural industries including the tree and ground nut crop industries.

Impacts Overseas

The scientific knowledge generated by this project and published in the scientific literature will have relevance to overseas horticultural industries who also have to manage aflatoxin levels in natural, ready-to-eat horticultural products. Reduced risk of a food safety incident will also benefit overseas consumers of Australian almonds.

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 to Rural RD&E Priority 2, and to Science and Research Priority 1 and 8.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	**Science and Research Priorities (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	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, 2015)

Alignment with the Almond Strategic Investment Plan 2017-2021

The strategic outcomes and strategies of the almond industry are outlined in the Almond Industry's Strategic Investment Plan 2017-2021[1] (Hort Innovation, 2017). Project AL11009 addressed Outcome 3, 'Pest and disease damage to almonds has been reduced through enhanced integrated pest management and integrated disease management' and the second part of Outcome 5, 'Increased export sales up from 61,000 t in 2016 to 110,000 t in 2022'.

Valuation of Impacts

Impacts Valued

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.

Two impacts were valued they were reduction in additional handling costs and reduction in value lost from Australian almond exports that fail to meet strict EU aflatoxin regulations.

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. Those not valued included:

- Reduction in loses associated with rots and spoilage when PVC stockpile covers are replaced with breathable alternatives.

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

- Increased researcher, grower, and supply chain partner skills in understanding and managing aflatoxin risk.
- Further reduction in the already small risk of illness associated with the consumption of Australia almonds and Australian almond products.
- Contribution to improved regional community wellbeing from spill-over benefits as a result of a stable, profitable almond industry - North Adelaide Plains, Riverland, Sunraysia and Riverina.

These impacts were not valued due to lack of data to support credible assumptions.

Summary of Assumptions

A summary of the key assumptions is provided in Table 6.

Table 6: Summary of Assumptions for Impact Valuation

Variable	Assumption	Source/Comment
Australian almond exports to the EU.	20,542 tonnes.	See Table 1 above.
EU rejection rate on Australian almonds.	5%	AL11009 project documentation.
EU rejection rate on Australian almonds with project recommendations in place.	2.5%	AL11009 project documentation.
Re-handling costs on almonds rejected by the EU including demurrage, warehousing, reprocessing, and replacement stock.	$1,500/tonne	AL11009 project documentation.
Value of almonds recovered with lower EU rejection rate.	$8,080/tonne	See Table 1 above.
Year in which EU rejection rate starts to decline.	2019	AgEconPlus – two years after project completion and postharvest management changes start to be implemented.
Year in which maximum adoption reached.	2024	AgEconPlus – 100% of industry production has now adopted.
Attribution of impacts to this project.	60%	Some impact attributable to past research including AL09207 scoping study.
Risk factors		
Probability of the project generating useful outputs that reduce aflatoxin risk.	100%	AgEconPlus – outputs have been communicated to growers.
Probability of impact (assuming successful outcome)	75%	AgEconPlus – there is some probability that growers will not successfully implement recommendations.
Counterfactual		
If Project AL11009 had not been funded there is a 50% chance that another source of funding or another research organisation would have completed the research.		
Proportion of benefits estimated that would have been delivered without Project AL11009.	50%	AgEconPlus.

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 (2016/17) 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.

Table 7: Investment Criteria for Total Investment in Project AL11009

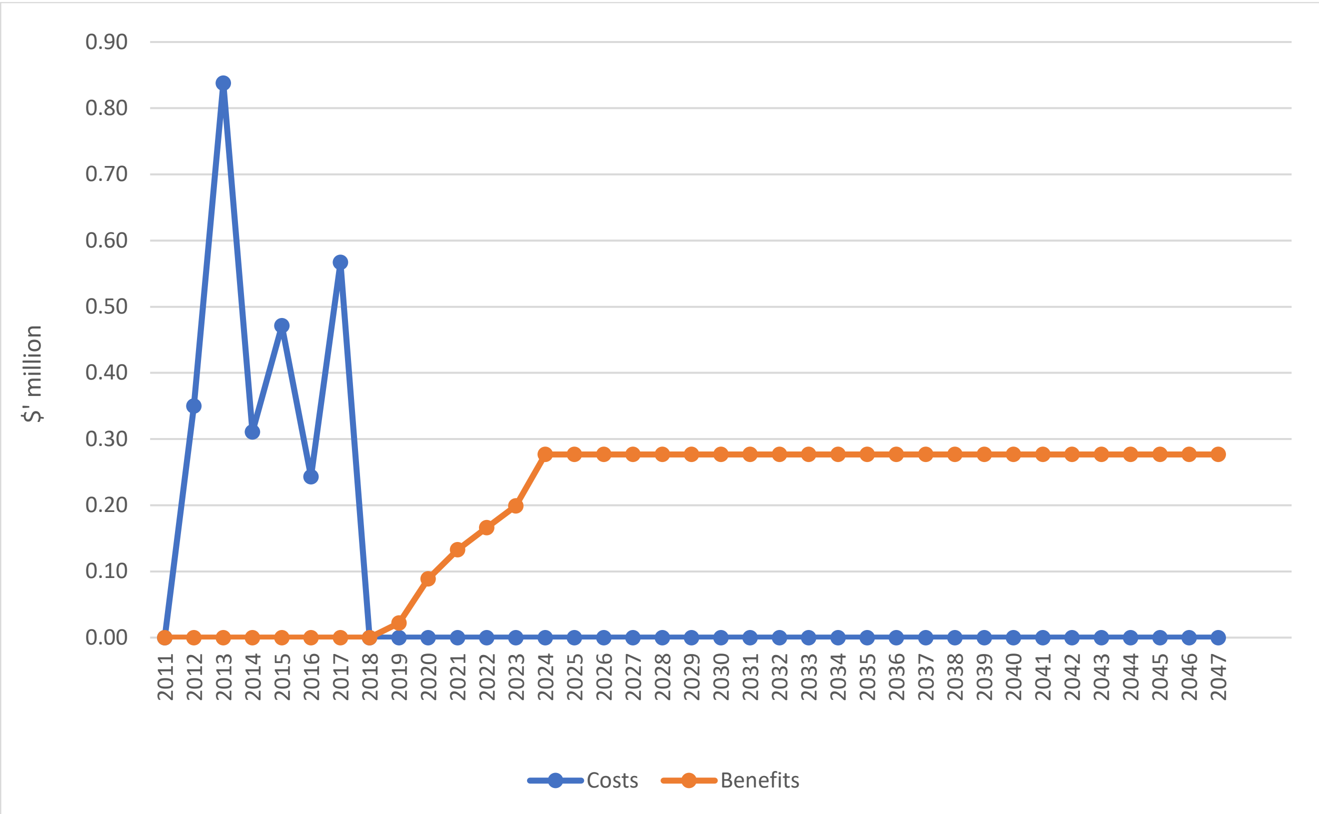
Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits ($m)	0.00	1.56	5.81	9.22	11.89	13.98	15.62
Present Value of Costs ($m)	3.67	3.67	3.67	3.67	3.67	3.67	3.67
Net Present Value ($m)	-3.67	-2.10	2.15	5.55	8.22	10.31	11.95
Benefit-Cost Ratio	0.00	0.43	1.59	2.52	3.24	3.81	4.26
Internal Rate of Return (%)	negative	negative	10.3	15.2	16.7	17.3	17.5
MIRR (%)	negative	negative	8.6	10.8	10.7	10.2	9.8

Table 8: Investment Criteria for Hort Innovation Investment in Project AL11009

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits ($m)	0.00	0.85	3.17	5.02	6.47	7.61	8.50
Present Value of Costs ($m)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Net Present Value ($m)	-2.00	-1.15	1.17	3.02	4.48	5.62	6.51
Benefit-Cost Ratio	0.00	0.43	1.59	2.52	3.24	3.81	4.26
Internal Rate of Return (%)	negative	negative	10.3	15.2	16.7	17.3	17.5
MIRR (%)	negative	negative	8.6	10.8	10.7	10.2	9.8

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the AL11009 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



Source of Benefits

Estimates of the relative contribution of each benefit valued, given the assumptions made, are shown in Table 9.

Table 9: Contribution to Total Benefits from Each Source

	Contribution to PVB ($m)	Share of Benefits (%)
Reduction in handling costs associated with EU rejections	2.45	15.7
Recovery in almond value lost due to EU rejections	13.17	84.3
Total	15.62	100.0

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 10 presents the results. The results show moderate sensitivity to the discount rate.

Table 10: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present Value of Benefits ($m)	29.22	15.62	9.70
Present Value of Costs ($m)	2.78	3.67	4.80
Net Present Value ($m)	26.44	11.95	4.90
Benefit-cost ratio	10.51	4.26	2.02

A sensitivity analysis was then undertaken for the share of almond crop adopting AL11009 findings. Results are provided in Table 11. Even when share of crop adopting project findings is reduced to a maximum of 25%, and given all other assumptions remaining unchanged, the project continues to show benefits greater than cost.

Table 11: Sensitivity to Share of Almond Crop Adopting AL11009 Project Findings
(Total investment, 30 years)

Investment Criteria	Share of Almond Crop Adopting Project Findings		
	25%	50%	100% (base)
Present Value of Benefits ($m)	3.86	7.81	15.62
Present Value of Costs ($m)	3.67	3.67	3.67
Net Present Value ($m)	0.19	4.14	11.95
Benefit-cost ratio	1.05	2.13	4.26

A final sensitivity analysis tested the sensitivity of the investment criteria to the assumed EU Australian almond rejection rate with project recommendations in place. The results (Table 12) show that even if the rejection rate improves by only 1%, project benefits exceed project costs.

Table 12: Sensitivity to EU Australian Almond Rejection Rate Post AL11009
(Total investment, 30 years)

Investment Criteria	EU Rejection Rate		
	1%	2.5% (base)	3%
Present Value of Benefits ($m)	6.25	15.62	18.74
Present Value of Costs ($m)	3.67	3.67	3.67
Net Present Value ($m)	2.58	11.95	15.08
Benefit-cost ratio	1.70	4.26	5.11

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 13). 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 13: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium-High	High

Coverage of benefits valued was assessed as Medium-High – while two key impacts were valued, others including an additional potential economic impact (reduced post-harvest crop loss) was not valued. Confidence in assumptions was rated as High, key data was provided by industry.

Conclusion

The investment in AL11009 has provided almond growers and supply chain partners with solutions to a major industry challenge that would limit future almond industry growth and profit. It has also provided additional surety on the safety of consuming Australian almonds.

Total funding from all sources for the project was $3.67 million (present value terms). The investment produced estimated total expected benefits of $16.11 million (present value terms). This gave a net present value of $12.44 million, an estimated benefit-cost ratio of 4.39 to 1, an internal rate of return of 17.9% and a modified internal rate of return of 9.9%.

As several of the identified impacts were not valued, the investment criteria estimated by the evaluation may be underestimates of the actual performance of the investment.

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.

Reference List

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Abbreviations

ABA	Almond Board of Australia
AL	Almond
BA	Banana
CRRDC	Council of Research and Development Corporations
CT	Citrus
DAWR	Department of Agriculture and Water Resources (Australian Government)
DEDTJR	(Victorian Govt) Department of Economic Development, Transport, Jobs and Resources
DPI	(Victorian Govt) Department of Primary Industries and part of DEDTJR
GDP	Gross Domestic Product
GVP	Gross Value of Production
IOD	Indian Ocean Dipole
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
OCS	Office of Chief Scientist Queensland
Ppb	parts per billion
PVB	Present Value of Benefits
RD&E	Research, Development and Extension
SARDI	South Australia Research and Development Institute
VN	Onion