Horticulture impact assessment program 2020-21 to 2022-23 (MT21015)

Annex 1: Impact assessment of the project cluster *Australian apple and pear industry innovation and adoption program (AP15004)* and *Delivery of apple and pear Future Orchards extension program (AP15005)*

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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 project cluster *Australian apple and pear industry innovation and adoption program (AP15004)* and *Delivery of apple and pear Future Orchards extension program (AP15005)*. The projects were funded by Hort Innovation over the period October 2015 to April 2021.

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 2020-21 dollar terms and were discounted to the year 2020-21 using a real (inflation-adjusted), risk free, pre-tax 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

AP15004 and AP15005 worked together to increase industry adoption of new innovations and best practices through a range of complimentary extension activities and outputs. In particular, the projects continued the Future Orchards program which originally commenced in 2006, helping to increase industry knowledge of best practice and new innovations, and thereby support earlier adoption and benefits than would otherwise have occurred.

The impacts valued were:

- [Economic] Earlier adoption of levy research outputs and industry best-practices, supporting increased farm productivity and profitability through:
  - Increased gross yield
  - Increased class 1 packout
  - Reduced input costs per kg of production.

Not all of the identified impacts could be valued in the assessment, particularly where there was a lack of credible data. These additional economic, social and environmental impacts have the potential to provide additional industry impact above what has been identified.

Investment criteria

Total funding from all sources for the project was $5.8 million (2021 equivalent value). The investment produced estimated total expected benefits of $9.6 million (2021 equivalent value). This gave a net present value of $3.9 million, an estimated benefit-cost ratio of 1.67 to 1, an internal rate of return of 20% and a modified internal rate of return of 7%.

Conclusions

To understand the benefits of an extension program, the adoption curve and orchard impact (benefits and costs) should be identified for all underlying R&D. This was deemed impractical given the scope of these impact assessments, so the impact was assessed based on a consolidated adoption curve and orchard impact. Credible estimates for the inputs were developed based on trend analysis of Orchard Business Analyst (OBA) data (AgFirst 2015-2022) and discussions with industry stakeholders.

Sensitivity was also undertaken to account for uncertainty in some of the variables, sensitivity testing was conducted that showed a BCR ranging from 0.82 to 2.52. The results were particularly sensitive to three key variables being: the value (market price) of the increased gross yield and class 1 packout; the extent to which the projects, or key activities and outputs, would have been delivered without Hort Innovation levy investment; the extent to which the projects increased adoption from what would have otherwise occurred.

Keywords

Impact assessment, cost-benefit analysis, apple and pear, extension, communications, Future Orchards

Introduction

Evaluating the impacts of levy investments is important to demonstrate to levy payers, Government and other industry stakeholders the economic, social and environmental outcomes of investment for industry, as well as being an important step to inform the ongoing investment agenda.

The importance of ex-post evaluation was recognised through the Horticulture Innovation Australia Limited (Hort Innovation) independent review of performance completed in 2017, and was incorporated into the Organisational Evaluation Framework.

Reflecting its commitment to continuous improvement in the delivery of levy funded research, development and extension (RD&E), Hort Innovation required a series of impact assessments to be carried out annually on a representative sample of investments of its RD&E portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation's Strategic Plan and the Evaluation Framework associated with Hort Innovation's Statutory Funding Agreement with the Commonwealth Government.
- Reporting against strategic priorities set out in the Strategic Investment Plan for each Hort Innovation industry fund.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

As part of its commitment to meeting these reporting requirements, Ag Econ was commissioned to deliver the *Horticulture Impact Assessment Program 2020-21 to 2022-23* (MT21015). This program consisted of an annual impact assessment of 15 randomly selected Hort Innovation RD&E investments (projects) each year.

Project *AP15005 Delivery of apple and pear Future Orchards extension program* was randomly selected as one of the 15 investments in the 2020-21 sample, given the close coordination and alignment of outcomes, AP15005 was clustered with *AP15004 Australian apple and pear industry innovation and adoption program* and evaluated as a single investment. This report presents the analysis and findings of the project cluster impact assessment.

General method

The 2020-21 population was defined as an RD&E investment where a final deliverable had been submitted in the 2020-21 financial year. This generated an initial population of 175 Hort Innovation investments, worth an estimated $101.14 million (nominal Hort Innovation investment). The population was then stratified according to the Hort Innovation RD&E research portfolios and five, pre-defined project size classes. Projects in the Frontiers Fund, and those of less than $80,000 Hort Innovation investment being removed from the sample. From the remaining eligible population of 59 projects, with a combined value of $39.51 million, a random sample of 15 projects was selected worth a total of $9.7 million (nominal Hort Innovation investment), equal to 25% of the eligible RD&E population (in nominal terms).

The impact assessment followed 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 included both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2018).

The evaluation process involved reviewing project contracts, milestones, and other documents; interviewing relevant Hort Innovation staff, project delivery partners, and growers and other industry stakeholders where appropriate; and collating additional industry and economic data where necessary. Through this process, the project activities, outputs, outcomes, and impacts were identified and briefly described; and the principal economic, environmental, and social impacts were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were 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 and rationale

Industry background

The Australian apple industry includes approximately 500 growers, while the pear industry includes approximately 255 growers (Hort Innovation 2022a). The combined apple and pear industries had a five year average production of 423 thousand tonnes (to year ending June 2021) decreasing an average 2% per year, and with a nominal production value of $658 million increasing at an average 7% per year (Hort Innovation 2022b). In 2020 Victoria accounted for approximately 46% of apple production and 90% of pear production. Approximately 65% of combined production went to the domestic fresh market, 33% to processing, and 3% to exports (Hort Innovation 2022a).

Producers in the apple and pear industries pay levies to the Department of Agriculture, Fisheries and Forestry (DAFF), who is responsible for the collection, administration and disbursement of levies and charges on behalf of Australian agricultural industries. Levy is payable on apples and pears that are produced in Australia and either sold by the producer or used by the producer in the production of other goods. Hort Innovation manages the apple and pear levy funds which are directed to R&D and marketing.

Rationale

The apple and pear industry's levy investments are guided by a Strategic Investment Plan (SIP). The Apple and Pear SIP 2017-21 (under which AP15005 was largely delivered) identified 'Industry profitability and global competitiveness is improved by reducing the average cost per carton' as a priority outcome for Australia's apple and pear industry. Increased knowledge and skills around best practice was identified as a key strategy to achieve this, with the Future Orchards program identified in particular as being is central to achieving this.

From 2016, the *Australian apple and pear industry innovation and adoption program* (AP15004) and *Delivery of apple and pear Future Orchards extension program* (AP15005) worked together to increase industry adoption of new innovations and best practices through a range of complimentary extension activities and outputs. In particular, the projects continued the Future Orchards program, which originally commenced in September 2006 with a vision to "provide Australian apple and pear growers with the technology and map they need to make their orchards globally competitive now and into the future".

Alignment with the Apple and Pear Strategic Investment Plan 2017-2021

With a focus on technology transfer to Australian apple and pear growers to support increased productivity and competitiveness, AP15004 and AP15004 were aligned to two outcomes of the Apple and Pear 2017-21 SIP:

- Outcome 1: Industry profitability and global competitiveness is improved by reducing the average cost per carton.
- Outcome 3: A cultural shift across industry has better equipped growers for long-term sustainability.

Alignment with national priorities

The Australian Government's National RD&E priorities (2015a) and Science and Research Priorities (2015b) are reproduced in Table 1. The AP15005 and AP15004 project cluster outcomes impacts contribute to RD&E Priority 4, and to Science and Research Priority 1.

Table 1. National Agricultural Innovation Priorities and Science and Research Priorities

Australian Government	
National RD&E Priorities (2015a)	**Science and Research Priorities (2015b)**
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.

Project details

Summary

Table 2. Project details

Project code	AP15004	AP15005
Title	*Australian apple and pear industry innovation and adoption program*	*Delivery of apple and pear Future Orchards extension program*
Research organization	Apple & Pear Australian Limited (APAL)	AgFirst Hawkes Bay Limited
Project leader	Rosalie Daniel	Ross Wilson
Funding period	March 2016 to April 2021	October 2015 to September 2020

Logical framework

A logical framework is shown in Table 3 to highlight the connection between the project activities, outputs, outcomes, and impact.

Table 3. Project logical framework

Activities	• Together, AP15004 and AP15005 coordinated a wide range of complimentary activities and events to support the adoption of best practice orchard management among the apple and pear industry. • The projects also undertook industry development and coordination activities including the collection, analysis and dissemination orchard of benchmarking data (AP15005) and the appointment of an industry Technical Manager (AP15004) to provide comprehensive technical support around biosecurity preparedness and response, crop protection stewardship, targeted post-harvest improvements, export preparedness, and grower services.
Outputs	• The Future Orchards program (delivered jointly through AP15004 and AP15005). ○ One Focus Orchard in each region (8 in total)

	○ 13 Orchard Walks each in eight locations (104 in total), average 300 growers per walk with estimated 75% of production. ○ 55 magazine articles ○ Free access for growers to the online orchard management tool, OrchardNet. ○ 30 Business Development Newsletters ○ 16 applied demonstration trials per year (two in each region) ○ APAL Future Orchard website library with all content sorted by subject ○ Five Annual Orchard Business Analysis (OBA) reports ○ Six Productivity Irrigation, Pests and Soils phase 2 (PIPS2 R&D extension events • Appointment of a Technical Manager (AP15004) • Four pear Masterclasses (AP15004) • Three Speed updating and one Technical Day (AP15004) • Postharvest seminars (AP15004). • 66 regional demonstration trials (AP15004) • Two regional study tours (AP15004) • Two international study tours (AP15004).
Outcomes	• The primary outcome of AP15004 and AP15005 was to increase apple and pear industry knowledge of best practice and new innovations, thereby supporting earlier adoption than would otherwise have occurred. A mid-term evaluation highlighted the strength of the program, and particularly the Orchard Walks of Future Orchards, as being its ability to "challenge and present new thinking beyond the grower's immediate network and encourage the acceleration of innovation and adoption through practical learning and the sharing of ideas". Focus areas for extension through the program included: ○ Labour needs, skills, management, efficiency, platforms, mechanisation ○ Tree variety mix, rootstocks, tree architecture, tools, new technologies ○ Eating quality, fruit size, colour, storage, timing, consumer appeal ○ Climate risk and mitigation, irrigation management, netting, frost, ○ Future Orchard – what it will take to be an orchard of the future? ○ Managing an orchard in a global pandemic • Additional outcomes included: ○ Increased knowledge of business benchmarking through OrchardNet against own-business and wider industry benchmarks and trends. ○ Increased industry capacity to benchmark production against an Australian model orchard through the OBA reports, supporting broader industry analysis and insight. ○ Increased growers' knowledge of the R&D and marketing levy processes. ○ Increased capacity and coordination at an industry level through the Technical Manager including for issues such as biosecurity risk management and market access.
Impacts	• [Economic] Earlier adoption of levy research outputs and industry best-practices, supporting increased farm productivity (value of outputs per value of inputs) and profitability through: ○ Increased gross yield ○ Increased class 1 packout ○ Reduced input costs per kg of production. • [Economic] Reduced biosecurity risk faced by the apple and pear industries through improved coordination. • [Economic] Improved export market access supporting greater opportunity to sustainably expand supply while maintaining farmgate prices. • [Social] Increased contribution to regional community wellbeing from more profitable apple and pear growers. • [Social] Increased sustainability of quality and affordable apple and pear supply, supporting consumption of apples and pears with associated health and wellbeing benefits. • [Environmental] Increased environmentally sustainable production from adoption of industry best practice.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)		Other ($)	Total ($)
	AP15005	AP15004		
2016	193,155	653,501	0	846,656
2017	210,103	517,824	0	727,927
2018	210,103	517,824	0	727,927
2019	210,103	517,824	0	727,927
2020	210,103	517,907	0	728,010
2021	114,841	258,912	0	373,753
2022	0	-165,682	0	-165,682
Total	1,148,408	2,818,112	0	3,966,520

Program management costs

R&D costs should also include the administrative and overhead costs associated with managing and supporting the project. The Hort Innovation overhead and administrative costs were calculated for each project funding year based on the data presented in the *Statement of Comprehensive Income* in the *Hort Innovation Annual Report* for the relevant year. Where the overhead and administrative costs were equal to the total expenses, less the research and development and marketing expenses. The overhead and administrative costs were then calculated as a proportion of combined project expenses (RD&E and marketing), averaging 15.9% for the AP15004 and AP15005 funding period. This figure was then applied to the nominal Hort Innovation investment shown in Table 4.

Real investment costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2020-21 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022).

Extension costs

AP15004 and AP15005 delivered an extension program for apple and pear innovation and best practice. Some of the underlying R&D extended through the program included separate communication and extension activities. As such, extension through AP15004 and AP15005 re-enforced existing channels to increase awareness above that which would otherwise have occurred.

Project impacts

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 valued

The impacts valued were:

- [Economic] Earlier adoption of levy research outputs and industry best-practices, supporting increased farm productivity and profitability through:
  - Increased gross yield
  - Increased class 1 packout
  - Reduced input costs per kg of production.

The earlier adoption of innovations and best practice was quantified through a shift in the adoption curve. The adoption curve and shift were calculated by increasing the CSIRO ADOPT framework metrics relating to the learnability of the

population including advisory support, group involvement, skills requirement, and innovation awareness (see Appendix A). This shift resulted in the innovation benefits being achieved earlier than they otherwise would have. The innovation benefits were calculated based on OBA data for a representative orchard, showing increased gross yield per hectare and class 1 packout from the commencement of the innovation and adoption program in 2017. These increases were partly attributed to AP15004 and AP15005 in recognition of additional factors affecting farm productivity. Increased costs per hectare were also calculated from the OBA data, reflecting the increased marginal cost associated with achieving the yield and class 1 gains. However, with the combined yield, class 1, and cost increases, average costs per kg of fruit decreased. The net farm level benefits were then aggregated to an industry level for both the slower adoption curve (without AP15004 and AP15005) and faster adoption curve (with AP15004 and AP15005). The benefit of AP15004 and AP15005 was then calculated as the difference between the slower and faster adoption curves.

Impacts not valued

Not all of the impacts identified in Table 3 could be valued in the assessment, particularly where there was a lack of data to quantify the identified impact. Identified extension impacts not valued included:

- [Economic] Reduced biosecurity risk faced by the apple and pear industries through improved coordination.
- [Economic] Improved export market access supporting greater opportunity to sustainably expand supply while maintaining farmgate prices.
- [Social] Increased contribution to regional community wellbeing from more profitable apple and pear growers.
- [Social] Increased sustainability of quality and affordable apple and pear supply, supporting consumption of apples and pears with associated health and wellbeing benefits.

Public versus private impacts

The impacts identified from the investment are predominantly private impacts accruing to apple and pear growers and supply chain participants. However, some public benefits also have been produced in the form of increased industry capacity, spillovers to regional communities from enhanced grower yield and income, and increased affordability of apples and pears to incorporate into a healthy diet.

Distribution of private impacts

This analysis quantified private benefits accruing to apple and pear growers. Additional spillover private impacts would be generated in the wider economy. Changes in farm input costs would result in corresponding spillover changes in income for businesses providing those goods and services. The total private impacts will have been further redistributed between growers, processor/packers, wholesalers, exporters, and retailers depending on both short- and long-term supply and demand elasticities.

Impacts on other Australian industries

Some of the extended R&D, including labour management and climate variability, may also be relevant to growers who produce other tree fruits with similar production systems.

Impacts overseas

The extension program had a focus on Australian apple and pear stakeholders. Furthermore, given Australia's low level of production in global terms, and limited export focus of 3% of production, the overseas impacts will be limited.

Data and assumptions

A summary of the key assumptions made in the assessment is provided in Table 5.

Table 5. Summary of assumptions for impact valuation

Variable	Assumption	Source / comment
Discount rate	5% (± 50%)	CRRDC Guidelines (2018)
Impact start	2017 season	Analysts assumption, key extension activities and outputs were conducted towards the end of the 2016 season.

Annual production (t)	423,178 (± 3%)	Australian Horticulture Statistics Handbook, 5 year average 2017-2021 (Hort Innovation 2022b).
Time to max adoption without projects	14 years	ADOPT model output (see Appendix A). ADOPT inputs based off target population having reduced awareness of, and skills, and advisory support for orchard innovations and best practice without the industry innovation and adoption program.
Reduced time to max adoption with projects (years reduction from without projects time)	6 years (± 33%)	ADOPT model output (see Appendix A). ADOPT inputs based off target population having increased awareness and knowledge of orchard innovations and best practice due to industry innovation and adoption program.
Max adoption (% of industry annual production)	65% (± 9%)	AP15005 final report identified 70% to 80% of industry production was exposed to the project, and further, that the majority of participants (frequently 90-100%) reported leaving events having learned something that they were likely to try on their own orchard. Lower adoption level of 75% x 95% = 71%. ADOPT framework results show likely industry adoption of 59% (see Appendix A). Midpoint of 65%.
Yield gain with innovation	6% (± 65%)	From OBA data (AgFirst, 2015-2022) and in consultation with stakeholders, comparing the pre-project 5-year average yield (42.4 t/ha (± 11%)) and yield reported during the project period (47.7 t/ha (± 8%)), but assuming that not all of the reported yield gain was attributable to the underlying innovations adopted through the program (attribution tested at 25, 50% (base), and 75%) with the remainder attributable to other innovations or factors.
Class 1 gain with innovation	1.8% (± 57%)	From OBA data (AgFirst, 2015-2022) and in consultation with stakeholders, comparing the pre-project average class 1 (68% (± 2%)) and class 1 reported during the project period (70% t/ha (± 3%)), but assuming that not all of the reported class 1 gain was attributable to the underlying innovations adopted through the program (attribution tested at 25, 50% (base), and 75%) with the remainder attributable to other innovations or factors.
Class 1 return ($/kg)	$2.28 (± 11%)	OBA data (AgFirst, 2015-2022) 2017-2021 average and standard deviation, inflation adjusted to 2021.
Class 2 and processing return ($/kg)	$0.53 (± 22%)	OBA data (AgFirst, 2015-2022) 2017-2021 average and standard deviation, inflation adjusted to 2021.
Cost of adoption ($/ha/yr increase)	$4,498 (± 65%)	Calculated based on OBA data (AgFirst, 2015-2022) for yield relative to per hectare costs, inflation adjusted to 2021, which showed a strong linear relationship of cost $/ha = 1644.9*gross yield -7965.2 (R-squared = 0.85), and applying baseline yield data and innovation yield gain as above. The marginal increase in costs/ha reflect the higher orchard management costs of best practice innovation (nutrition, canopy management, &c) to achieve the yield and class 1 packout increases as above, with a net effect of a decrease in costs/kg.
R&D counterfactual	50% (± 50%)	Following completion of AP15004 and AP15005, the Future Orchards and OBA program was directly funded by APAL, indicating moderate likelihood that this could have occurred from 2016-2021, negating the need for apple and pear levy funds.

Results

Investment criteria

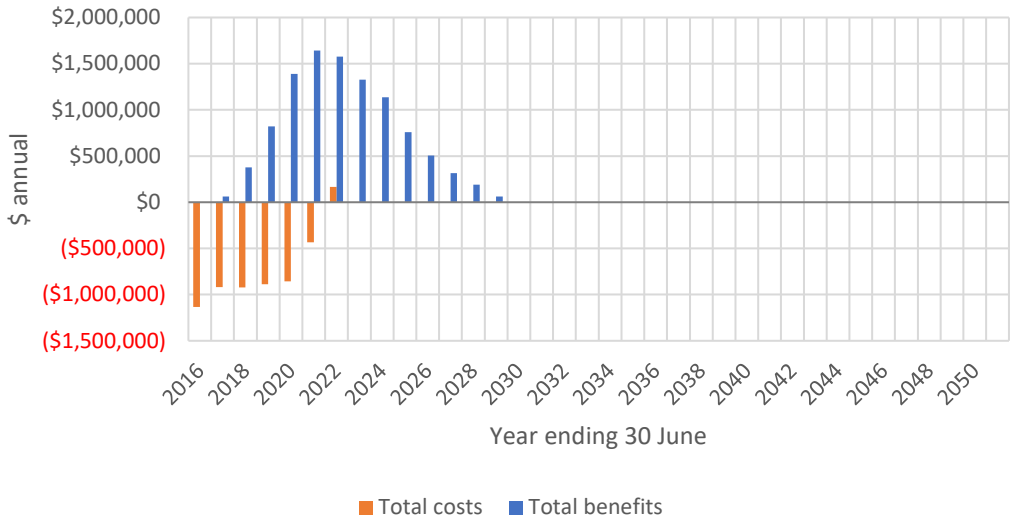
Table 6 shows the impact metrics estimated for different periods of benefit for the total investment. Hort Innovation was the only investor in AP15004 and AP15005.

Table 6. Impact metrics for the total investment in project AP15004 and AP15005

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	5.94	5.78	5.78	5.78	5.78	5.78	5.78
PVB ($m)	4.52	9.23	9.64	9.64	9.64	9.64	9.64
NPV ($m)	-1.42	3.44	3.86	3.86	3.86	3.86	3.86
BCR	0.76	1.60	1.67	1.67	1.67	1.67	1.67
IRR	Negative	19%	20%	20%	20%	20%	20%
MIRR	Negative	13%	11%	9%	8%	8%	7%

Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment in AP15004 and AP15005. Cash flows are shown for the duration of the investment plus 30 years from the last year of investment.

Figure 1. Annual cash flow of undiscounted total benefits and total investment costs



Sensitivity analysis

A sensitivity analysis was carried out on key variables identified in the analysis where a data range was identified, or there was a level of uncertainty around the data (Table 7). Data ranges and sources are described in Table 5.

Table 7. Impact BCR sensitivity to changes in key underlying variables

Variable		Low	Baseline	High
Discount rate	Variable range	2.5%	5.0%	7.5%
	BCR range	1.84	1.67	1.52
Baseline industry production (t)	Variable range	411,501	423,178	434,855
	BCR range	1.62	1.67	1.71
Max adoption (share of production)	Variable range	71%	65%	59%
	BCR range	1.82	1.67	1.51
Gross yield gain (t/ha)	Variable range	2.3%	6.4%	10.6%
	BCR range	1.42	1.67	1.91
Class 1 gain (%)	Variable range	0.8%	1.8%	2.8%
	BCR range	0.88	1.67	2.46
Class 1 farmgate price ($/kg)	Variable range	2.0	2.3	2.5
	BCR range	0.82	1.67	2.52
Other fruit farmgate price ($/kg)	Variable range	0.42	0.53	0.65
	BCR range	1.61	1.67	1.72
Increased adoption speed (years)	Variable range	4	6	8
	BCR range	0.83	1.67	2.16
R&D counterfactual	Variable range	25.0%	50.0%	75.0%
	BCR range	0.83	1.67	2.50

Discussion and conclusions

The analysis showed that the quantified benefits were marginally greater than the investment costs for AP15004 and AP15005, with a BCR 1.67:1. The results reflect the benefit of earlier industry awareness and knowledge relating to apple and pear orchard innovation and best practice. This outcome was assessed to increase the speed of adoption of orchard innovations and best practice, thereby increasing the speed of gross yield and class 1 fruit recovery improvement and associated industry profitability.

Extension is a key step in the impact pathway off R&D and can make the difference between rapid or slow industry adoption and impact. The degree to which a good extension program can shift the adoption curve compared to a poor extension program will in part depend on the specifics of the innovation being adopted. For consolidated extension programs, such as that provided by AP15004 and AP15005, a wide range of existing R&D is drawn upon. To understand the benefits of an extension program, the adoption curve and orchard impact (benefits and costs) would have to be identified for all underlying R&D. This was deemed impractical given the scope of this impact assessment, so the impact was assessed based on a consolidated adoption curve and orchard impact. While all efforts were made to provide credible estimates for the inputs, based on trend analysis of OBA data (AgFirst 2015-2022) and discussions with industry stakeholders, there nevertheless remains a higher level of uncertainty compared to a typical impact assessment of a single innovation's RD&E.

To account for the uncertainty in some of the variables, sensitivity testing was conducted that showed a BCR ranging from 0.82 to 2.52. The results were most sensitive to the tested ranges of three inputs:

- Class 1 price. The value of increased gross yield and class 1 packout is largely dependent on the underlying class 1 price. This was modelled at the 5-year inflation adjusted average price $2.28 (± 11%).
- Counterfactual attribution. The extent to which AP15005 and AP15004 would have been delivered without Hort Innovation levy investment. As key extension vehicles, such as Future Orchards, were funded by APAL following completion of AP15004 and AP15005, there was assumed to be a reasonable (50%, tested at 25% and 75%)

likelihood that these earlier iterations of the innovation and adoption plan could have been funded by APAL.

- Increased adoption speed. This was the key outcome attributed to AP15004 and AP15005. The with- and without-project adoption was calculated through the CSIRO ADOPT framework by adjusting key parameters relating to apple and pear stakeholder awareness and knowledge of the innovations (see Appendix A). The shift in adoption was tested at ±50%.

A lack of underlying data meant that there were also social outcomes identified but not quantified which had the potential to provide additional impact to the apple and pear industry.

The analysis quantified private benefits accruing to apple and pear growers. Additional spillover impacts would be generated in the wider economy. The adoption of innovations and best practice resulted in increased orchard management costs such as pruning, thinning, pest and disease, nutrition, and pollination. In addition, the resultant increase in yield and class 1 resulted in increased post-harvest costs including cold storage, transport, and commissions. While these reflect a cost to growers they would result in corresponding spillover changes in income for employees and businesses providing those goods and services.

The CRRDC Guidelines focusses on first round impacts, which calculates shifts in the supply and demand curves with no price effect. When considering these second-round price effects RD&E that focusses on increased productivity would support increased industry supply, and thereby put downward pressure on prices, effectively shifting some of the benefit from producers to consumers. The extent to which this would occur would depend on the slope of the supply and demand curves. Given the low level of exports in the apple and pear industry, there is a reduced capacity for the market to absorb increased supply without a decrease in prices.

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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.
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.

Abbreviations

ADOPT The Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Adoption & Diffusion Outcome Prediction Tool (Kuehne et al 2017)

CRRDC Council of Rural Research and Development Corporations

DAFF Department of Agriculture, Fisheries and Forestry (Australian Government)

GDP Gross Domestic Product

IRR Internal Rate of Return

MIRR Modified Internal Rate of Return

PVB Present Value of Benefits

PVC Present Value of Costs

RD&E Research, Development and Extension

SIP Strategic Investment Plan

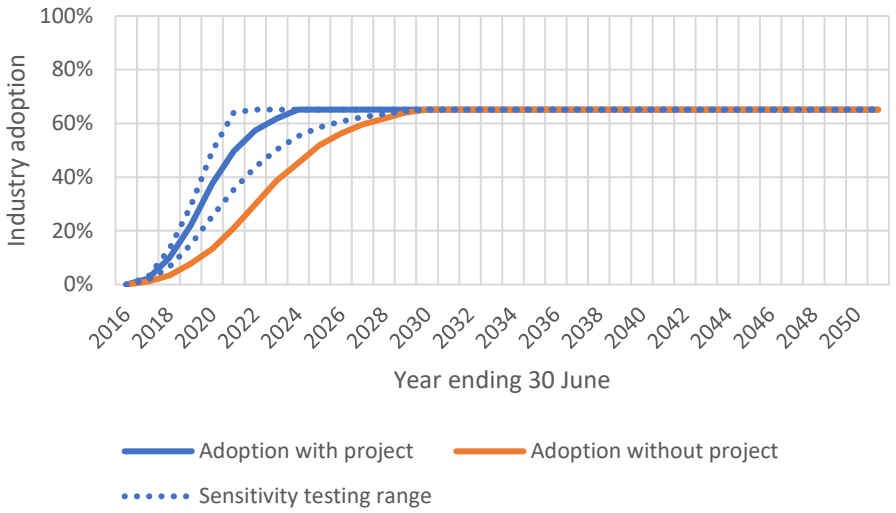
PIPS Productivity Irrigation, Pests and Soils

OBA Orchard Business Analyst

Appendix A. ADOPT questions and answers for AP15004 and AP15005 impact assessment

Appendix A includes the data inputs for the ADOPT model (Kuehne et al 2017) used in this analysis. AP15004 and AP15005 were assessed to result in increased stakeholder awareness, skills and resources (questions 10 to 13) relating to apple and pear innovation and best practice. This in turn supported a more rapid industry adoption than would otherwise have occurred. This assessed shift in the adoption and diffusion curve can be seen in Figure 2.

Figure 2. Change in adoption and diffusion curve from AP15004 and AP15005 generating increased awareness, knowledge and resources relating to apple and pear innovation and best-practice. Includes sensitivity testing of ±50% of the baseline yearly change.



1. What proportion of farmers have maximising profit as a strong motivation?
A majority have maximising profit as a strong motivation

2. What proportion of farmers has protecting the natural environment as a strong motivation?
About half have protection of the environment as a strong motivation

3. What proportion of farmers has risk minimisation as a strong motivation?
About half have risk minimisation as a strong motivation

4. On what proportion of farmers is there a major enterprise that could benefit from the technology?
Almost all of the target farms have a major enterprise that could benefit

5. What proportion of farmers have a long-term (greater than 10 years) management horizon for their farm?
About half have a long-term management horizon

6. What proportion of farmers are under conditions of severe short-term financial constraints?
A minority currently have a severe short-term financial constraint

7. How easily can the innovation be trialled on a limited basis before a decision is made to adopt it on a larger scale?
Moderately trialable

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?
Moderately difficult to evaluate effects of use due to complexity

9. To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district?
Moderately observable

10. What proportion growers use paid advisors capable of providing advice relevant to the project?
Without AP15004 and AP15005 a minority use a relevant advisor

With AP15004 and AP15005 almost all use a relevant advisor

11. What proportion of growers participate in farmer-based groups that discuss farming?

Without AP15004 and AP15005 a minority are involved with a group that discusses farming

With AP15004 and AP15005 almost all are involved with a group that discusses farming

12. What proportion of growers will need to develop substantial new skills and knowledge to use the innovation?
Without AP15004 and AP15005 about a majority will need new skills or knowledge

With AP15004 and AP15005 about almost none will need new skills or knowledge

13. What proportion of growers would be aware of this innovation in their district?
Without AP15004 and AP15005 a minority would be aware of the use or trialling of this innovation in their district

With AP15004 and AP15005 almost all would be aware of the use or trialling of this innovation in their district

14. What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation?
No initial investment required

15. To what extent is the adoption of the innovation able to be reversed?
Moderately easily reversed

16. To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used?
Small profit advantage in years that it is used

17 To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business?
Moderate profit advantage or disadvantage in the future

18 How long after the innovation is first adopted would it take for effects on future profitability to be realised?
1-2 years

19. To what extent would the use of the innovation have net environmental benefits or costs?
Nil environmental benefit or cost

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?
Not applicable

21. To what extent would the use of the innovation affect the net exposure of the farm business to risk?
No change in risk

22. To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used?
No change in ease and convenience