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

Annex 2: Impact assessment of *An integrated pest, disease and weed management program for the Australian apple and pear industry* (AP16007)

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Contents

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 *AP16007 An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry*. The project was funded by Hort Innovation over the period September 2017 to September 2020.

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

AP16007 increased apple and pear grower and advisor awareness, knowledge, skills and resources relating to integrated pest and disease management (IPDM). As a result, AP16007 supported an earlier adoption of IPDM than would otherwise have occurred.

The impacts valued were:

- Earlier adoption of cost-effective and low-risk IPMD, resulting in:
  - [Economic] A reduction in average pest management operating costs while sustaining or improving marketable yield.

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 $1.29 million (2021 equivalent value). The investment produced estimated total expected benefits of $2.99 million (2021 equivalent value). This gave a net present value of $1.70 million, an estimated benefit-cost ratio of 2.32 to 1, an internal rate of return of 27% and a modified internal rate of return of 8%.

Conclusions

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. In this context, it is important to recognise that the analysis does not quantify the full benefit of IPDM adoption, but only the benefit of earlier IPDM adoption.

Sensitivity testing was also undertaken to account for uncertainty in some of the variables, sensitivity testing was conducted that showed a BCR ranging from 1.16 to 3.14. The results were particularly sensitive to two variables: the extent to which the project increased the speed of IPDM adoption from what would have otherwise occurred; and the proportion of industry that made (earlier) IPDM practice changes as a result of AP16007.

Keywords

Impact assessment, cost-benefit analysis, apple and pear, extension, communications, integrated pest and disease management, IPDM, integrated pest management, IPM

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 *AP16007 An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry* was randomly selected as one of the 15 investments in the 2020-21 sample. This report presents the analysis and findings of the project 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 industries levy investments are guided by a Strategic Investment Plan (SIP). The Apple and Pear SIP 2017-21 (under which AP16007 was delivered) identified 'Industry profitability and global competitiveness is improved by reducing the average cost per carton' as a priority outcome for Australia's combined apple and pear industry, including a strategy focus to "continue to build the body of knowledge around pest and disease management and prevention, considering both biosecurity risk mitigation and cost reduction".

The Productivity Irrigation, Pests and Soils (PIPS) program (PIPS1 2009 to 2014, and PIPS2 2015 to 2020) had conducted extensive RD&E to build the body of knowledge around integrated pest and disease management (IPDM). The researched considered risk mitigation in terms of both the yield impacts of pests, and the cost impacts of pest management. The PIPS program developed new integrated pest and disease management (IPDM) tools and recommendations for use by fruit growers.

The 2016 to 2017 project *A needs analysis for integrated pest management (IPM) R&D in the Apple and Pear Industry* (AP15014) set out to provide a better understanding of the use of IPM within the apple and pear industry and the efficacy of the existing IPM Manual in guiding practice.

AP15014 found that while awareness of IPM was high, adoption of true IPM by the industry was low – while 86 per cent of growers surveyed believed they were using IPM, further investigation suggested that, by the technical definition, only 25 per cent actually were, with the ongoing use of harsh chemicals undermining many IPM approaches. While an independent assessment estimated that IPDM refinement through the PIPs program reduced pesticide costs by 3% (Hort Innovation 2021), AP15014 identified a grower and advisor perception that IPM entailed increased risks, either from pest damage or increased costs of surveillance or both. AP15014 further found that all the tools required to allow growers to use IPM effectively were already available and being used by some, but grower and advisor confidence in IPM could stand to be increased across the industry. On-farm demonstrations and updating of the IPM Manual were recommended approaches to achieve this.

Based on the recommendations of AP15014, project AP16007 was initiated to review, synthesise and extend current knowledge of IPDM in apple and pear orchards, particularly those new to the industry, and to update the IPM manual (including to encompass IPDM). The objective was to assist the industry to clearly communicate IPDM and the risks involved, to give the industry the confidence, knowledge and skills to adopt, implement and sustain a cost-effective low-risk IPDM-based farming system that would be resilient to changes in regulatory policy and new pest incursions that impact pest management options.

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

With a focus on improving knowledge and skills of IPM within the Australian apple and pear industry, AP16007 was 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 AP16007 project outcomes and related impacts will 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	AP16007
Title	*An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry*
Research organization	Agriculture Victoria, Department of Jobs Precincts and regions
Project leader	David Williams
Funding period	September 2017 to September 2020

Logical framework

Table 4. Project logical framework

Activities	• A team of experts with knowledge of each growing region were assembled to review existing IPDM information and provide region specific guidelines and training to engage growers and advisors. Regional differences in pest and disease issues were taken into consideration, and information on potential impacts of exotic incursions was provided. • In particular, AP16007 extension was largely based on material produced from the PIPS program.
Outputs	• A revised IPDM manual was developed, designed to suit various platforms that growers and advisors identified as preferred methods for receiving information. • Two IPDM training sessions conducted in each apple and pear growing state. • Grower case studies for each apple and pear growing state following IPDM adoption and outcomes. • A Community of Practice was established to share experiences and knowledge. • A dedicated IPDM website was developed to centralise information, tools and resources, including an *Ask an Expert* service whereby national experts provide timely answers to questions submitted by growers, agronomists and other service providers.

Outcomes	• AP16007 surveys reported increased awareness, knowledge, skills and resources relating to IPDM:
	  ○ An average 20% increase in grower and advisor confidence to identify pests, diseases, weeds and beneficials and the understanding of their lifecycles.
	  ○ A 24% increase in growers using historical records in management decisions.
	  ○ An average 20% increase in the use of monitoring results, predictive models, warning services, and action thresholds to determine the need for.

	• Growers have a wider network of growers, researchers, and advisors, to discuss IPDM and other apple and pear farming issues.
Impacts	• Earlier adoption of cost-effective low-risk IPDM, supporting: ○ [Economic] A reduction in average pest and disease management operating costs while sustaining or improving marketable yield. ○ [Economic] Increased resilience to changes in regulatory policy ○ [Economic] Improved adherence to chemical residue limits for key markets. ○ [Economic] Improved social licence from an enhanced image of clean and green production, supporting confidence for ongoing investment in the industry. ○ [Social] Increased contribution to regional community wellbeing from more profitable apple and pear growers. ○ [Social] Ensuring a sustainable supply of quality apples and pears, thereby supporting increased fruit consumption with associated health and wellbeing outcomes ○ [Environmental] Reduced negative externalities including environmental impacts from high usage of harsh chemicals.

Project costs

Nominal investment

Table 3. Project nominal investment

Year end 30 June	Hort Innovation ($)	AgVic DPIR ($)	Total ($)
2018	103,086	85,677	188,763
2019	300,027	249,359	549,386
2020	53,179	44,198	97,377
2021	114,074	94,809	208,883
Total	570,366	474,044	1,044,410

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 16.1% for the AP16007 funding period (2018-2021). This figure was then applied to the nominal Hort Innovation investment shown in Table 3.

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

AP16007 was an extension project. AP16007 extension materials drew particularly from the PIPS program. As such, this analysis could be viewed as being largely a PIPS extension program, generating faster adoption and earlier benefits, than would have been achieved with the pre-existing PIPS extension framework.

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:

- Earlier adoption of cost-effective and low-risk IPMD, resulting in:
  - [Economic] A reduction in average pest management operating costs while sustaining or improving marketable yield.

The earlier adoption of IPDM 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, innovation skills, and innovation awareness (see Appendix A). This shift resulted in the benefits of IPDM (reduced pest and disease managment costs while increases or sustaining class 1 packout) being achieved earlier than they otherwise would have. For both the slower adoption curve (without AP16007) and faster adoption curve (with AP16007) the full industry innovation impact was calculated. The benefit of AP16007 was then calculated as the difference between the slower and faster adoption curves.

Impacts not valued

Not all of the impacts identified in Table 4 could be valued in the assessment, particularly where there was a lack of data to quantify the identified impact. Other communication impacts not valued included:

- Earlier adoption of cost-effective low-risk IPDM, supporting:
  - [Economic] Increased resilience to changes in regulatory policy
  - [Economic] Improved adherence to chemical residue limits for key markets.
  - [Economic] Improved social licence from an enhanced image of clean and green production, supporting confidence for ongoing investment in the industry.
  - [Social] Increased contribution to regional community wellbeing from more profitable apple and pear growers.
  - [Social] Ensuring a sustainable supply of quality apples and pears, thereby supporting increased fruit consumption with associated health and wellbeing outcomes
  - [Environmental] Reduced negative externalities including environmental impacts from high usage of harsh chemicals.

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 have also been produced in the form of capacity built and spill-overs to regional communities from enhanced grower yield and income, improved environmental outcomes, 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 (increase or decrease) would result in spillover changes (increase or decrease) 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

The extended IPDM may also be relevant to growers who produce other tree fruits with similar production systems and pests.

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)
Annual production (t)	423,178 (± 3%)	Hort Stats Handbook 5y av & sdev (Hort Innovation 2022b)
Industry adoption through AP16007	46% (± 27%)	563 growers in the apple and pear industry. AP16007 had 190 workshop attendees; lower adoption of 190/563=34% of production. ADOPT output (see Appendix 1) showed maximum adoption of 59%; taken as the upper adoption. Midpoint of 46%.
Adoption start	2018-19	The first IPM training sessions were in August 2018.
Time peak adoption (without AP16007 extension)	Max adoption 14 years	ADOPT model output. See Appendix A.
Time to peak adoption (with AP16007 extension)	Max adoption 9 years	ADOPT model output with the resulting adoption curve shift from the baseline tested at (± 50%). See Appendix A.
Pest and disease management cost decrease with IPDM	$7.15 / t gross yield (± 39%)	OBA data (AgFirst, 2015-2022) in consultation with stakeholder, comparing the pre-project 4-year average (2014-2017) pest and disease management costs ($89/t ±15%) to that reported during the project period ($74/t ±10%), all figures inflation adjusted to 2021, but assuming that not all of the reported cost change was attributable to the underlying IPDM adopted through the program (attribution tested at 25, 50% (base), and 75%) with the remainder attributable to other innovations or factors.
Class 1 packout increase with IPDM	0.4% (± 100%)	OBA data (AgFirst, 2015-2022) in consultation with stakeholders, comparing the pre-project 4-year average class 1 packout (69% ±4%) to that reported during the project period (70% ±3%), but assuming that not all of the reported class 1 gain was attributable to the underlying IPDM adopted through the program (attribution tested at 25, 50% (base), and 75%) with the remainder attributable to other innovations or factors.
Marketable yield based costs	$979 / t class 1 (± 4%)	Increased class 1 results in an increase in marketable yield based costs including packaging, transport and commissions. OBA data (AgFirst, 2015-2022), 4-year average post harvest costs (2018-2021). Inflation adjusted to 2021.
Other operational costs	$766 / t gross yield (± 4%)	OBA data (AgFirst, 2015-2022), 4-year average (2018-2021) total costs less post-harvest and pest and disease management. Inflation adjusted to 2021. Unchanged with new IPDM practices.
Attribution of outcome (faster adoption)	75% (± 50%)	AP16007 had some limited coordination with Future Orchards (AP15005 and AP15004) extension.
R&D counterfactual	75% (± 50%)	In discussion with stakeholders it was assumed that there was only a small likelihood the investment and outcomes would have been delivered without Hort Innovation levy contribution and coordination.

Results

All costs and benefits were discounted to 2020-21 using a real 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 (2020-21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment criteria

Table 6 shows the impact metrics estimated for different periods of benefit for the total investment.

Table 6. Impact metrics for the total investment in project AP16007

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	1.29	1.29	1.29	1.29	1.29	1.29	1.29
PVB ($m)	0.46	2.49	2.99	2.99	2.99	2.99	2.99
NPV ($m)	-0.83	1.20	1.70	1.70	1.70	1.70	1.70
BCR	0.35	1.93	2.32	2.32	2.32	2.32	2.32
IRR	Negative	25%	27%	27%	27%	27%	27%
MIRR	Negative	14%	13%	11%	9%	9%	8%

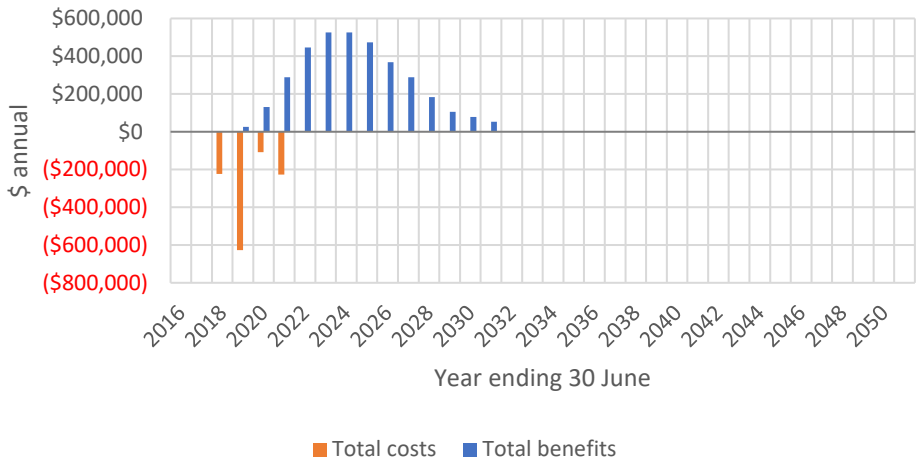
Table 7 shows the impact metrics estimated for different periods of benefit for the Hort Innovation investment. The benefits attributable to Hort Innovation were based on a total funding share (including admin costs) of 58%.

Table 7. Impact metrics for the Hort Innovation investment in project AP16007

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	0.75	0.75	0.75	0.75	0.75	0.75	0.75
PVB ($m)	0.27	1.45	1.74	1.74	1.74	1.74	1.74
NPV ($m)	-0.49	0.70	0.99	0.99	0.99	0.99	0.99
BCR	0.35	1.93	2.32	2.32	2.32	2.32	2.32
IRR	#NUM!	25%	27%	27%	27%	27%	27%
MIRR	-35%	14%	13%	11%	9%	9%	8%

Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of AP16007. 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 6. Sensitivity of impact (total investment BCR) to changes in key underlying variables

Variable		Low	Baseline	High
Discount rate	Variable range	3%	5%	8%
	BCR range	2.61	2.32	2.07
Industry production (t)	Variable range	411,501	423,178	434,855
	BCR range	2.26	2.32	2.38
Increased adoption speed (years) from AP16007	Variable range	1	2	3
	BCR range	1.16	2.32	3.14
Max adoption through AP16007	Variable range	34%	46%	59%
	BCR range	1.69	2.32	2.95
PDM cost change	Variable range	-12%	-8%	-4%
	BCR range	2.96	2.32	1.68
Class 1 packout change	Variable range	0.00%	0.44%	0.88%
	BCR range	1.93	2.32	2.71
Class 1 farmgate price ($/kg)	Variable range	2.04	2.28	2.53
	BCR range	1.96	2.32	2.68
Other farmgate price ($/kg)	Variable range	0.42	0.53	0.65
	BCR range	2.49	2.32	2.15
Marketable yield based costs ($/t)	Variable range	939	979	1,019
	BCR range	2.38	2.32	2.26
Attribution of outcome (faster adoption) to AP16007	Variable range	50%	75%	100%
	BCR range	1.55	2.32	3.09
R&D counterfactual	Variable range	50%	75%	100%
	BCR range	1.55	2.32	3.09

Conclusions

The analysis showed that the quantified benefits were greater than the investment costs for AP16007, with a BCR 2.32:1. The results reflect the benefit of earlier industry awareness, knowledge, and skills relating to apple and pear IPDM. This outcome was assessed to increase the speed of adoption of IPDM, thereby bringing forward the associated benefits including reduced average PDM costs and increased average class 1 fruit recovery.

Extension is a key step in the impact pathway off R&D and can make the difference between a rapid or slow industry adoption and impact. In this context, it is important to recognise that the final impact value does not include the full benefit of IPDM adoption, but only the benefit of earlier IPDM adoption.

AP16007 extension materials drew particularly from the PIPS program. As such, this analysis could be viewed as being largely a PIPS extension program, generating faster adoption and earlier benefits, than would have been achieved with the pre-existing PIPS extension framework.

To account for the variability in the underlying data, sensitivity testing was conducted that showed a BCR ranging from 1.16 to 3.14. The results were most sensitive to the tested ranges of two inputs:

- Increased adoption speed. The extent to which the project increased the speed of IPDM adoption from what would have otherwise occurred was the key outcome attributed to AP16007. The with- and without-project adoption was calculated through the CSIRO ADOPT framework by adjusting key parameters relating to stakeholder awareness and

knowledge of the innovations (see Appendix A).

- Maximum adoption level. Prior to AP16007 it was found that while awareness of IPDM was high at around 86%, adoption was only 25%. Based on combined grower and advisor participation in AP16007, the project was assumed to have supported (earlier) IPDM practice change by 46% including through project attendance and additional communication through consultant and word-of-mouth channels. It is important to note that this analysis assumed the 46% of industry involved in the program would likely have adopted the IPDM practices without AP16007, but as a result of increased knowledge, skills, and resources this adoption and the benefits were brought forward. This was consistent with discussions with project stakeholders who noted that many of the participants were already moving along the IPDM pathway, but participation in the project gave them confidence to take greater steps.

A lack of underlying data meant that there were economic, social and environmental 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. Adoption of IPDM practice have associated changes in orchard management costs such as reduced chemical use, and increased monitoring costs. At the same time, improved class 1 packout results in increased post-harvest costs such as packaging, transport, and marketing. Changes in these costs would result in corresponding spillover changes in income businesses providing those goods and services which would generate additional impact above that quantified in this analysis.

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 (increased average class 1 packout and decreased average costs) 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

GVP Gross Value of Production

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

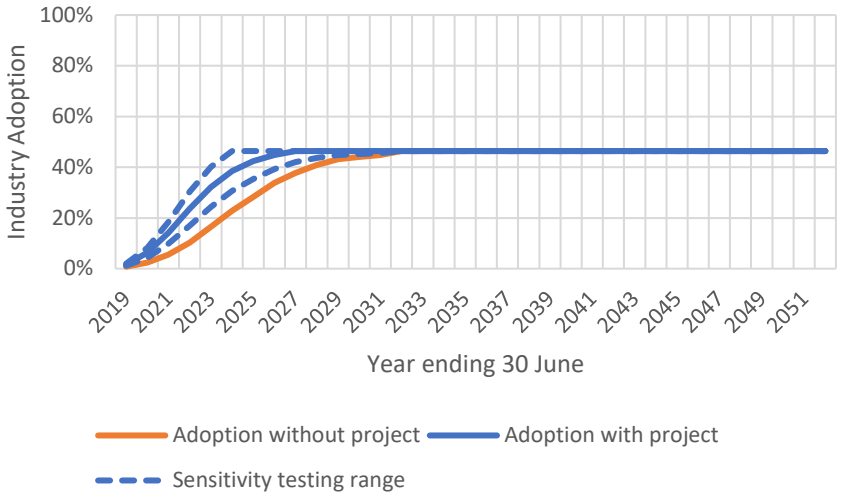
SIP Strategic Investment Plan

PIPS Productivity Irrigation, Pests and Soils

OBA Orchard Business Analyst

Appendix A. ADOPT questions and answers for AP16007 impact assessment

Appendix A includes the data inputs for the ADOPT model (Kuehne et al 2017) used in this analysis. Inputs were developed based project outputs and in consultation with project stakeholders. AP16007 reported that the knowledge and confidence of growers to adopt IPDM increased by about 20% during the life of the project as a result of the project activities and outputs, as well as an increased use of consultants, and on-going support via the Community of Practice. As a result, AP16007 was assessed to result in increased awareness, knowledge, skills and resources (questions 10 to 13) relating to apple and pear IPDM. 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. Based on the ADOPT output and grower and advisor participation, maximum adoption supported by AP16007 was estimated at 46% of industry (ranging from 34% to 59%).



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?
Very easily trialable

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?
Not at all 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?
Not observable at all

10. What proportion growers use paid advisors capable of providing advice relevant to the project?
About half use a relevant advisor without AP16007
A majority use a relevant advisor with AP16007

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

About half are involved with a group that discusses farming without AP16007
A majority are involved with a group that discusses farming with AP16007

12. What proportion of growers will need to develop substantial new skills and knowledge to use the innovation?
Almost all will need new skills or knowledge without AP16007
A minority will need new skills or knowledge with AP16007

13. What proportion of growers would be aware of the use or trialling of the innovation in their district?
A minority are aware without AP16007
A majority are aware with AP16007

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?
Very 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?
No 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?
Not applicable

19. To what extent would the use of the innovation have net environmental benefits or costs?
Moderate environmental advantage

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?
Immediately

21. To what extent would the use of the innovation affect the net exposure of the farm business to risk?
Small reduction 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?
Small decrease in ease and convenience