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

Annex 6: Impact assessment of the project *Australian macadamia industry innovation and adoption program* (MC15004)

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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 *MC15004 Australian Macadamia Industry Innovation and Adoption Program*. The project was funded by Hort Innovation over the period March 2016 to February 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

MC15004 increased industry increased industry knowledge of best practice and new innovations through a range of complimentary extension activities and outputs thereby supporting earlier adoption and benefits than would otherwise have occurred.

The impacts valued were:

- Earlier adoption of industry innovation and best practices, including improved canopy management, orchard floor and soil health, irrigation and drainage, pest and disease management, and nutrition, supporting:
  - [Economic] Increased nut in shell (NIS) yield while maintaining SKR.

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 $2.8 (2021 equivalent value). The investment produced estimated total expected benefits of $5.6 million (2021 equivalent value). This gave a net present value of $2.8 million, an estimated benefit-cost ratio of 1.99 to 1, an internal rate of return of 63% and a MIRR of 9%.

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 innovation adoption curve and orchard impact. Credible estimates for the inputs were developed based on trend analysis of Macadamia Benchmarking data (DAF QLD-2021) and discussions with industry stakeholders.

Sensitivity testing was also undertaken to account for uncertainty in some of the variables, sensitivity testing was conducted that showed a BCR ranging from 0.99 to 2.89. The results were particularly sensitive to three key variables being: the extent to which the project increased adoption from what would have otherwise occurred; the NIS yield gain that could be attributed to the underlying innovations and best practice being extended; and the extent to which the project, or key activities and outputs, would have been delivered without Hort Innovation levy investment.

Keywords

Impact assessment, cost-benefit analysis, macadamia, extension, communication, adoption

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 *MC15004 Australian Macadamia Industry Innovation and Adoption Program* 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 sample was defined as an RD&E investment where a final deliverable had been submitted in the 2020-21 financial year. This generated an overall 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, a random sample of 15 projects was selected worth a total of approximately $12.5 million (nominal Hort Innovation investment), equal to 12% of the total RD&E population (in nominal terms).

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 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 five-year project was delivered during a time of significant industry expansion. In 2016, the industry consisted of about 650 growers and 17,000 ha planted to macadamias, while in 2021 this had increased to about 800 growers and 32,500 ha, of which approximately 25,000 ha were bearing (Hort Innovation 2022a). In 2022, the industry was continuing to expand rapidly, with substantial new plantings underway in new and existing regions (AMS, 2022). At the same time, strong international growth in macadamia production—particularly in African countries, as well as China, Vietnam and South America—meant that Australia's historical dominance of global production was slipping (ABC, 2021).

Producers in the macadamia industry 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 macadamias 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 macadamia levy funds which are directed to R&D and marketing.

Rationale

Ongoing growth in areas planted to macadamias around the world and the focus on maintaining Australia's reputation as a supplier of premium nuts highlighted the importance of a strategic and industrywide approach to increasing production and profitability. This was seen to be complicated by the number of new growers who had and were continuing to enter the industry, many with little knowledge of macadamia production and management.

As a result, the industry saw the need for an extension strategy that recognised the significant range of skills and background in the industry— from corporate managers with a successful history of growing macadamias, through to inexperienced new entrants establishing small and medium-sized orchards—to ensure that research outcomes were maximised.

Alignment with the Macadamia Strategic Investment Plan 2017-2021

MC15004 was closely aligned to Outcome 3 of the Macadamia 2017-21 SIP: *Improved capacity to lead and support current and future industry needs*, and specifically Strategy 1, *Continue to support adoption of R&D outputs by effective extension*.

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 MC15004 project outcomes and related 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	MC15004
Title	*Australian Macadamia Industry Innovation and Adoption Program*
Research organization	Australian Macadamia Society (AMS)
Project leader	Leoni Kojetin
Funding period	March 2016 to February 2021

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	• Project MC15004 employed a dedicated macadamia industry productivity development manager (MIPDM). • The MIPDM worked with other Australian Macadamia Society staff members such as the industry communications manager and the industry market development manager, as well as processor, industry and agency extension advisors, to take the outputs from Hort Innovation's macadamia R&D program and apply them using extension techniques such as peer-to-peer learning. • The MIPDM was also responsible for undertaking constant engagement with growers and the wider industry to manage emerging issues, and identify and develop new opportunities for the industry. • MC15004 extension activities were supported by a number of projects, state agencies and a range of other resources but in particular the project worked very closely with MC18000 - Australian Macadamia Industry Communications Program. • MC15004 was focused around six key delivery areas, which were managed according to an annual extension operating plan. *1.* Review and understand current production constraints. *2.* Assist in the development of new research outcomes. *3.* Develop the agreed industry macro extension issue annually. *4.* Identify and develop opportunities for new orchard and territory expansion. *5.* Manage unforeseen emerging issues. *6.* Deliver research outcomes and agreed industry issues.
Outputs	• 75 MacGroups were held with a total of 5665 attendances in all key growing regions covering key strategic issues identified through consultation with growers and stakeholders. • 13 additional workshops on nursery standards, environmental monitoring, tree water relations, soil health, and pollination. • Five targeted workshops were held for new growers. • 113 articles as author, joint author or providing technical input in the quarterly News Bulletin as well as involvement in developing technical features for each edition. • Five two-day industry consultants group workshop to promote consultation between service providers, identify emerging and macro issues and agree on strategic approaches to extending R&D outcomes. • A study tour for growers to China in 2018 and to South Africa in 2019, as well as attending the International Macadamia Symposiums. • 19 AMS YouTube videos and four AMS Podcasts of interviews with growers and technical specialists on topical issues. • 15 factsheets featuring new information and research outcomes about orchard management. • 29 field days and workshops showcasing best practice and innovative techniques.

	• Member of the organising committee for two AMS Conference as well as presenting papers, liaising with speakers, developing programs and coordinating special sessions. • Organizing annual *Awards of Excellence* to identify high performing growers and to showcase their on-farm practices to the wider industry
Outcomes	• Stakeholders have increased knowledge, attitudes, skills and aspirations (KASA) relating to industry innovation and research outputs including improved canopy management, orchard floor and soil health, irrigation and drainage, pest and disease management, and nutrition, supporting: ○ Earlier adoption of industry innovation and best practices than would otherwise have occurred. • Stakeholders have increased confidence in the R&D being conducted and the industry level support for the macadamia industry. • AMS staff, macadamia growers, and the supply chain have additional skills in liaison, extension, innovation, and production, supporting broader industry outcomes including improved issues identification and R&D planning. • Increased coordination with other Australian tree crop industries, and international macadamia producers, supporting increased knowledge transfer, and innovation awareness and adoption. • Stakeholders have increased awareness of issues regarding rural-urban interface including social responsibilities, managing spray drift, neighbour relations, trees under powerlines and protecting managed pollinators. • Increased coordination between growers and researchers involved research such as pollination trials, disease management trials and other IPDM research, enabling investigations to be completed on farm at commercial scale and in a representative portion of growing regions.

Impacts	• Earlier adoption of industry innovation and best practices, including improved canopy management, orchard floor and soil health, irrigation and drainage, pest and disease management, and nutrition, supporting:
	  ○ [Economic] Increased nut in shell (NIS) yield.
	  ○ [Economic] Maintained or increased Saleable Kernel Recovery (SKR).
	• [Economic] A more sustainable expansion of the macadamia industry, supporting increased overall production while maintaining quality standards and Australia's position as a premium supplier.
	• [Economic] Improved issues management relating to unforeseen events, minimising negative impacts on the industry.
	• [Social] Increased contribution to regional community wellbeing from more profitable and sustainable macadamia growers.
	• [Social] Increased sustainability of quality and affordable macadamias, thereby supporting increased nut consumption with associated health outcomes.
	• [Environmental] Increased environmentally sustainable production from adoption of industry best practice.
	• [Economic] Improved alignment of R&D to industry issues, and ability to deliver outputs and outcomes that are commercially proven on farm, have credibility, are practical in focus and are directly applicable to the industry, further supporting increased R&D adoption and impact.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)	AMS ($)	Total ($)
2016	397,304	814	398,118
2017	308,116	631	308,747
2018	318,488	653	319,141
2019	309,010	633	309,643
2020	308,146	631	308,778
2021	352,261	722	352,983
Total	1,993,326	4,084	1,997,410

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 15.9% for the MC15004 funding period (2016-2021). 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

MC15004 delivered an extension program for macadamia innovation and best practice. Some of the underlying R&D extended through MC15004 included separate communication and extension activities. As such, extension through MC15004 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:

- Earlier adoption of industry innovation and best practices, including improved canopy management, orchard floor and soil health, irrigation and drainage, pest and disease management, and nutrition, supporting:
  - [Economic] Increased NIS yield while maintaining SKR.

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, new skills requirement, and innovation awareness (see Appendix A). This shift resulted in the innovation benefits (increased NIS while maintaining increased SKR) being achieved earlier than they otherwise would have. For both the slower adoption curve (without MC15004) and faster adoption curve (with MC15004) the full impact was calculated for this group. The benefit of MC15004 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 pathway. Identified impacts not valued included:

- [Economic] A more sustainable expansion of the macadamia industry, supporting increased overall production while maintaining quality standards and Australia's position as a premium supplier.
- [Economic] Improved issues management relating to unforeseen events, minimising negative impacts on the industry.
- [Social] Increased contribution to regional community wellbeing from more profitable and sustainable macadamia growers.
- [Social] Increased sustainability of quality and affordable macadamias, thereby supporting increased nut consumption with associated health outcomes.
- [Environmental] Increased environmentally sustainable production from adoption of industry best practice.
- [Economic] Improved alignment of R&D to industry issues, and ability to deliver outputs and outcomes that are commercially proven on farm, have credibility, are practical in focus and are directly applicable to the industry, further supporting increased R&D adoption and impact.

Public versus private impacts

The impacts identified from the investment are predominantly private impacts accruing to macadamia 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 supply and affordability of macadamias to incorporate into a healthy diet.

Distribution of private impacts

This analysis quantified private benefits accruing to macadamia 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, wholesalers, exporters, and retailers depending on both short- and long-term supply and demand elasticities.

Impacts on other Australian industries

The project included increased coordination with other Australian tree crop industries, potentially supporting knowledge transfer and innovation adoption in those industries.

Impacts overseas

The project included increased coordination with international macadamia producers, potentially supporting knowledge transfer and innovation adoption in those countries. In addition, given Australia's high level of production in global terms, and strong export focus of 79% of production (5 year average, Hort Innovation 2022a), increased productivity and profitability in Australia has the potential to impact global supply and price depending on underlying global supply and demand elasticities.

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, MC15005 commenced in March 2016, towards the end of the 2016 season.
Annual industry production (t KWE)	15,500 (± 7%)	Australian Horticulture Statistics Handbook, 5 year average 2017-2021 and standard deviation.
Max adoption (% of industry annual production)	48% (± 38%)	Discussions with industry stakeholders indicated that the primary beneficiaries of the extension and communication

		program were medium sized growers. For these growers, macadamia farming is likely their sole income, and they likely have a strong drive for continuous improvement in line with industry best practice, but they don't necessarily have the resources to stay on top of new industry innovations and recommendations without the support of a consolidated extension program such as MC15004. In contrast, smaller growers may have different goals that don't necessarily require staying at the forefront of best practice, nor the resources to implement the changes. Finally, larger growers would already have the internal capacity to identify and implement new innovations, with a reduced need to gain this information from a consolidated industry innovation and adoption program. While macadamia benchmarking data (DAF QLD, 2021) did not break down total production by farm size, benchmark data for farm size indicated medium sized farms (20-50 ha) made up around 30% of production. If expanded to 10-100 ha, the share of production increased to 67%. An adoption range of 30% to 67% of production was used, with a 48% midpoint.
Time to max adoption without projects	8 years	ADOPT model output (see Appendix A). ADOPT inputs based off target population having reduced awareness, knowledge, and skills relating to 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)	3 years (± 33%)	ADOPT model output (see Appendix A). ADOPT inputs based off target population having increased awareness, knowledge, and skills relating to orchard innovations and best practice due to participation in the industry innovation and adoption program.
NIS yield gain with innovation	20% (± 45%)	Macadamia Benchmarking data (DAF QLD, 2021) shows medium sized farms had an average yield of 2.8 t/ha from 2009-2020, which equated to the 50th percentile of all mature farms. It was assumed that adoption of innovations and best practice would increase NIS yield to between the 60th percentile (3.1 t/ha an 11% increase) and 70th percentile (3.6 t/ha, a 29% increase) with a midpoint of 3.4 t/ha (20% increase).
Price $/kg KWE	$15.54 (± 44%)	Australian Horticulture Statistics Handbook, 5 year average 2017-2021.
Cost of adoption ($/ha/yr increase)	$708 (± 45%)	Calculated based on Macadamia Benchmarking data (DAF QLD, 2021) for yield relative to per hectare costs, which showed a positive relationship of cost to yield of approximately costs $/ha = 1283.3*NIS yield+5469.4. The with- and without-innovation NIS yields were applied to this to calculate the higher orchard management costs reflecting adoption of best practice innovation (nutrition, canopy management, &c) to achieve the higher NIS yield, as well as higher yield related costs (transport &c).
R&D counterfactual	75% (± 33%)	While there is a high level of support from industry for the project, a low level of funding outside of Hort Innovation managed levy funds indicates a low probability that the project would be funding to the same extent without the contribution of levy funds.

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

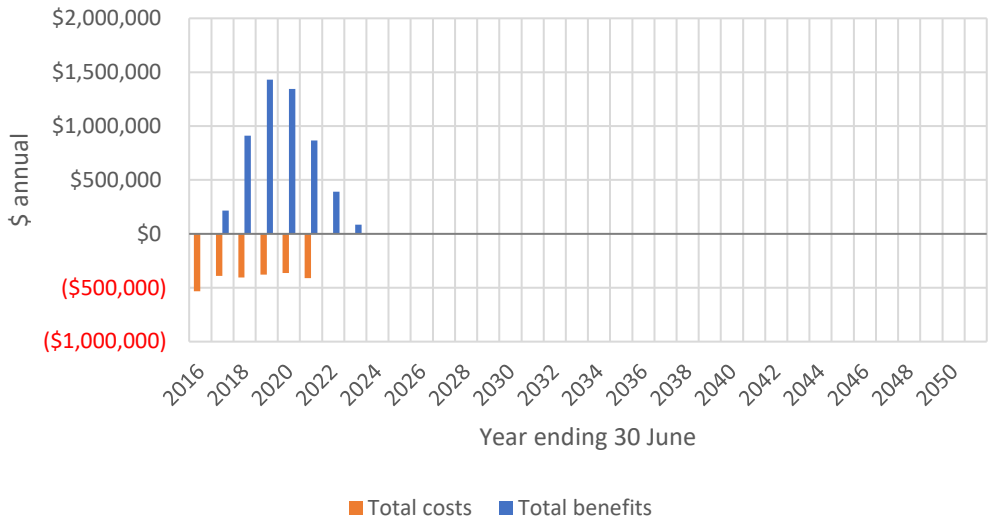
Table 6 shows the impact metrics estimated for different periods of benefit for the total investment. Hort Innovation was the only investor in MC15004.

Table 6. Impact metrics for the total investment in project MC15004

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	2.83	2.83	2.83	2.83	2.83	2.83	2.83
PVB ($m)	5.17	5.62	5.62	5.62	5.62	5.62	5.62
NPV ($m)	2.35	2.80	2.80	2.80	2.80	2.80	2.80
BCR	1.83	1.99	1.99	1.99	1.99	1.99	1.99
IRR	43%	62%	63%	63%	63%	63%	63%
MIRR	36%	21%	15%	13%	11%	10%	9%

Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of MC15004. 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	3%	5%	8%
	BCR range	2.05	1.99	1.93
Baseline industry production (t)	Variable range	1,4436	1,5500	1,6565
	BCR range	1.85	1.99	2.13
Max adoption (share of production)	Variable range	30%	50%	70%
	BCR range	1.23	1.99	2.75
NIS yield gain (t/ha)	Variable range	0.11	20%	29%
	BCR range	1.08	1.99	2.89
Farmgate price ($/kg)	Variable range	12.51	15.54	18.57
	BCR range	1.46	1.99	2.51
Increased adoption speed (years)	Variable range	2	3	4
	BCR range	0.99	1.99	2.61
Counterfactual attribution	Variable range	0.50	0.75	1.00
	BCR range	1.33	1.99	2.65

Discussion and conclusions

The analysis showed that the quantified benefits were marginally greater than the investment costs for MC15004, with a BCR 1.99:1. The results reflect the benefit of earlier industry awareness and knowledge relating to macadamia 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 NIS yield and SKR 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 an average extension program will in part depend on the specifics of the innovations being adopted. To understand the benefits of a consolidated industry extension program (such as MC15004), the adoption curve and orchard impact would have to be identified for all underlying innovations (i.e. the RD&E impact pathway would have to be quantified for each specific innovation). This was deemed impractical given the scope of this impact assessments, so the impact was assessed based on a combined innovation adoption curve and orchard impact. While all efforts were made to provide credible estimates for the inputs based on trend analysis of Macadamia Benchmarking data (DAF QLD, 2021) and discussions with industry stakeholders, there nevertheless remained a higher level of uncertainty compared to a typical impact assessment of a single innovation's RD&E impact pathway.

To account for the uncertainty in some of the variables, sensitivity testing was conducted that showed a BCR ranging from 0.99 to 2.89. The results were most sensitive to the tested ranges of three inputs:

- Increased adoption speed. This was the key outcome attributed to MC15004. The with- and without-project adoption was calculated through the CSIRO ADOPT framework by adjusting key parameters relating to macadamia stakeholder awareness, knowledge and skills that were deemed to have changed as a result of MC15004 (see Appendix A). The shift in adoption was tested at ±50%. BCR range 0.99 to 2.61.
- NIS yield gain with innovation. The yield gain reflects the benefits of the underlying innovations and best practice being extended through MC15004. While is tied to the underlying innovations being extended rather than MC15004, a higher productivity improvements from the innovations mean there is greater value in bringing forward industry adoption through improved extension . BCR range 1.08 to 2.89.
- Counterfactual attribution. The extent to which MC15004 would have been delivered without Hort Innovation levy investment. The investment was assumed to be largely dependent on levy fund contribution through Hort Innovation (75%, tested at 50% and 100%). BCR range 1.33 to 2.65.

A lack of underlying data meant that there were additional economic, social and environmental outcomes identified but not quantified which had the potential to provide additional impact to the macadamia industry. These have the potential to increase the industry impact above that identified in this analysis.

The analysis quantified private benefits accruing to macadamia growers; however, additional spillover impacts would be generated in the wider economy. Adoption of innovations and best practice have associated changes in orchard management costs such as canopy management, orchard floor and soil health, irrigation and drainage, pest and disease management, and nutrition, as well as additional yield based costs from increased yield (such as transport and marketing). These costs were not included in the quantified industry benefit to be consistent with previous Hort Innovation impact assessments, but 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 impact. In reality, 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. With a relatively high level of exports in the macadamia industry, there is higher 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

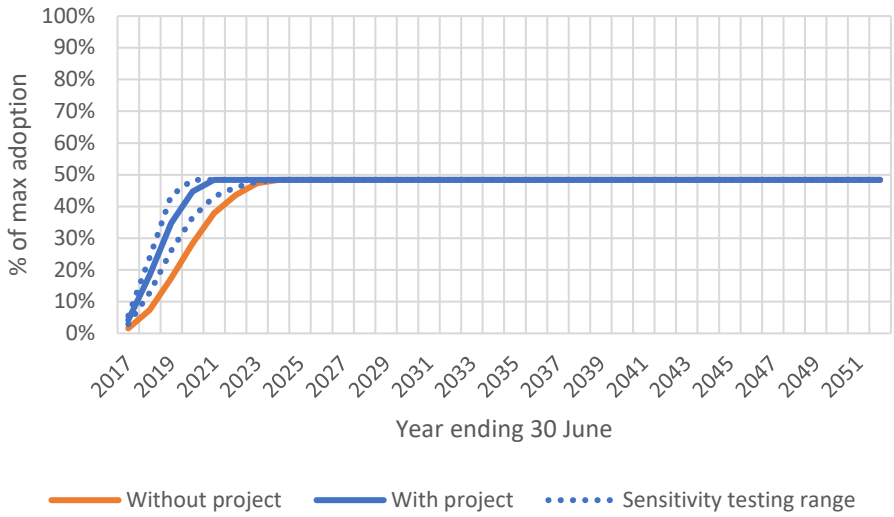
RD&E Research, Development and Extension

SIP Strategic Investment Plan

Appendix A. ADOPT questions and answers for MC15004 impact assessment

Appendix A includes the data inputs for the ADOPT model (Kuehne et al 2017) used in this analysis. In discussion with research and industry stakeholders, MC15004 was assessed to result in increased stakeholder awareness, knowledge, resources and skills (questions 10 to 13) relating to macadamia innovation and best practice. This in turn supported a more rapid industry adoption than would otherwise have occurred. Stakeholders indicated that the macadamia industry has a high level of grower level engagement, with regional grower groups providing a number of avenues for grower-to-grower engagement outside of MC15004. This assessed shift in the adoption and diffusion curve can be seen in Figure 2 in relation to the maximum adoption identified in Table 5.

Figure 2. Change in adoption and diffusion curve from MC15004 generating increased awareness, knowledge and resources relating to macadamia 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?
Easily trailable

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?
Slightly 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 MC15004 about half use a relevant advisor

With MC15004 almost all use a relevant advisor

11. What proportion of growers participate in farmer-based groups that discuss farming?
Without MC15004 about half are involved with a group that discusses farming

With MC15004 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 MC15004 about half will need new skills or knowledge

With MC15004 almost none will need new skills or knowledge

13. What proportion of growers would be aware of this innovation in their district?
Without MC15004 about half would be aware of the use or trialling of this innovation in their district

With MC15004 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 (part of ongoing management costs)

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?
Moderate 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 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?
Small environmental advantage

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?
1-2 years

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?
No change in ease and convenience