ACRE Economics

Queensland Government

Impact Assessments of Six Research, Development and Extension Investments by the Queensland Department of Agriculture and Fisheries 2022

Aggregate Analysis Summary Report

Final Report

Prepared For

The Queensland Department of Agriculture and Fisheries

Prepared By

Talia Hardaker

ACRE Economics Pty Ltd

Submitted

1 August 2022

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Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to previous drafts are in each of the individual appendices.

Abbreviations and Acronyms

BCR	Benefit-Cost Ratio
CBA	Cost Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries Queensland
FAS	Fish Attracting Structures
MIRR	Modified Internal Rate of Return
N	Nitrogen
NSW	New South Wales
QLD	Queensland
RD&E	Research, Development and Extension

Glossary of Economics Terms

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

Executive Summary

This report presents the assessment process, aggregate analysis, and associated findings of a series of six impact assessments of Queensland Department of Agriculture and Fisheries' (DAF) investment in research, development, and extension (RD&E). The investments evaluated were:

1. Legume Learnings in the Coastal Landscape (funded 2015/16 to 2019/20)
2. Fish Attracting Structures (funded 2017/18 to 2020/21)
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19 (funded 2020/21)
4. Grains Storage Best Management Practice (funded 2018/19 to 2020/21)
5. Mango Breeding Program (R2E2/Calypso) (funded 1977/78 to 1990/91 and 1995/96 to 2003/04)
6. Building Capacity for Nursery Biosecurity (funded 2015/16 to 2020/21)

Each investment level impact assessment followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations (RDCs), Cooperative Research Centres, State Departments of Agriculture, and some universities. The evaluation process followed an input to impact continuum and involved both qualitative and quantitative analysis components. The impact assessment approach used was in accord with the current guidelines of the Council of Rural RDCs.

The six DAF RD&E investments evaluated in the 2021/22 impact assessments produced a range of economic, environmental, and social impact types. All six DAF RD&E investments analysed produced positive investment criteria at a 5% discount rate over 30 years. The net present value (NPV) of the investments ranged from $0.68 million (Investment 3) to $262.36 million (Investment 5) and benefit-cost ratios (BCRs) ranged from 2.20 (Investment 1) to approximately 12.3 to 1 (Investments 4 and 5). The Table below shows the investment criteria for the total investment in each investment evaluated at 30 years from the last year of investment using a 5% discount rate.

Investment Criteria by Investment for the Total Investment (30 years, 5% discount rate)

Investment	**Present Value of Benefits ($m)**	**Present Value of Costs ($m)**	**NPV ($m)**	**BCR**	**Internal Rate of Return (IRR) (%)**	**Modified IRR (%)**
Investment 1: Legume Learnings in the Coastal Landscape	11.54	5.24	6.30	2.20	6.7	7.5
Investment 2: Fish Attracting Structures	5.55	1.85	3.70	3.01	7.1	8.5
Investment 3: Vegetable Exports	1.06	0.38	0.68	2.80	7.3	8.0
Investment 4: Grains Storage Best Management Practice	15.22	1.24	13.98	12.30	31.3	13.6
Investment 5: Mango Breeding Program (R2E2/Calypso)	285.53	23.18	262.36	12.32	10.5	10.4
Investment 6: Building Capacity for Nursery Biosecurity	14.46	3.57	10.89	4.05	12.6	9.2
Aggregate[(a)]	**333.37**	**35.45**	**297.92**	**9.40**	**10.5**	**9.3**

(a) The aggregate figure may differ from the sum of the individual investment results because of small rounding discrepancies.

The total aggregate investment in all six RD&E investments was estimated at $35.45 million (present value terms) and produced aggregate total expected net benefits of approximately $333.37 million (present value terms). This gave an estimated aggregate net present value of $297.92 million, an aggregate benefit-cost ratio (BCR) of 9.4 to 1, an aggregate internal rate of return (IRR) of 10.5% and an aggregate Modified IRR of 9.3%.

Across all six investments, the projects contributed either directly or indirectly to all five of the current DAF Strategic Objectives described in the DAF Strategic Plan 2021-2025. Overall, the results were highly positive and suggest that, in the aggregate, the six selected investments evaluated performed above average given reported average BCRs of between 4.5 and 5.5 to 1 for agricultural RD&E. The positive findings from the impact assessments of the six DAF RD&E investments should be viewed favourably by DAF, DAF funding partners, and industry stakeholders.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape (funded 2015/16 to 2019/20)
2. Fish Attracting Structures (funded 2017/18 to 2020/21)
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19 (funded 2020/21)
4. Grains Storage Best Management Practice (funded 2018/19 to 2020/21)
5. Mango Breeding Program (R2E2/Calypso) (funded 1977/78 to 1990/91 and 1995/96 to 2003/04)
6. Building Capacity for Nursery Biosecurity (funded 2015/16 to 2020/21)

This report presents a summary of the assessment process, an aggregate analysis, and associated aggregate findings across impact assessments of each of the six RD&E investments listed for the DAF 2021/22 evaluation. The individual investment evaluation reports are presented in Appendices A to F

Method

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

The evaluation process for each investment followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified for each investment were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

The undiscounted benefit and cost cash flows for each of the six RD&E investments evaluated then were aggregated and analysed together to generate aggregate investment criteria for all six investments for the total investment and for the DAF investment alone.

The individual investment evaluation reports are presented in Appendices A to F

Aggregate Nominal Investment

Table 1 shows the annual aggregate nominal investment made in by DAF and other contributors in all six RD&E investments.

Table 1: Total Nominal Investment in Six DAF RD&E Investments

Year (ended 30 June)	DAF ($)	Others ($)	Total ($)
1978	45,000	0	45,000
1979	45,000	0	45,000
1980	45,000	0	45,000
1981	45,000	0	45,000
1982	45,000	0	45,000
1983	45,000	0	45,000
1985	45,000	15,000	60,000
1986	45,000	15,000	60,000
1987	45,000	15,000	60,000
1988	45,000	15,000	60,000
1989	45,000	15,000	60,000
1990	45,000	15,000	60,000
1991	45,000	15,000	60,000
1992-1995	0	0	0
1996	66,000	66,000	132,000
1997	66,000	66,000	132,000
1998	66,000	66,000	132,000
1999	66,000	66,000	132,000
2000	66,000	66,000	132,000
2001	66,000	66,000	132,000
2002	66,000	66,000	132,000
2003	66,000	66,000	132,000
2004	66,000	66,000	132,000
2005-2015	0	0	0
2016	485,116	588,271	1,073,387
2017	678,182	729,999	1,408,181
2018	889,863	871,640	1,761,503
2019	1,247,428	903,656	2,151,084
2020	1,190,039	751,249	1,941,288
2021	850,455	408,475	1,258,930
Totals	**6,565,083**	**4,967,290**	**11,532,372**

Source: Project agreements and variations and consultation with DAF personnel

Impacts by Investment

Table 2 provides a summary of the principal types of potential impacts from the each of the six DAF RD&E investments assessed categorised using a triple bottom line framework into economic, environmental, and social impact types.

Table 2: Principal Potential Impact Types from Each of the Six DAF RD&E Investments

Investment	Economic Impacts	Environmental Impacts	Social Impacts
Investment 1: Legume Learnings in the Coastal Landscape	• Increased profitability of grain legume cropping industries in specified regions of QLD and Northern New South Wales (NSW). • Potential for increased area of various grain legume crops in each of the four nodes. • An increase in the benefits to other crops in the rotation (e.g., sugarcane and winter and summer cereals). • Increased efficiency/effectiveness of future RD&E resource allocation through identification and prioritisation of key industry issues and constraints.	• Improvement in soil health through increased adoption of legume crop rotations and reduced tillage. • Increased use of leguminous crops in rotations leading to reduced use of fertiliser N in some regional cropping systems (e.g., sugarcane), in turn leading to reduced export of mineralised nitrogen (N) to waterways.	• Increased capacity and capability of Queensland and northern NSW agronomists and extension personnel regarding grain legume production and crop rotational strategies. • A potential increase in positive regional spillover impacts from future gains in productivity and incomes in regional cropping systems in QLD and northern NSW.
Investment 2: Fish Attracting Structures	• Increased future income for tourism related businesses in regional communities where freshwater fish attracting structures (FAS) are constructed and installed to increase the in-flow of intra-state and inter-state regional angling tourists.	• Nil.	• Driving the increased flow of regional tourism, the investment in FAS has improved recreational amenity for local anglers and intra-state/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed.

Investment 2: Fish Attracting Structures	• The implementation of FAS may result in some increased costs for community groups, such as fishing and stocking clubs, or regional councils for construction, installation, promotion, and monitoring of FAS in regional impoundments.		
Investment 3: Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19	• A contribution to additional profitable sales for vegetable growers (broccoli, green beans, sweet corn, iceberg lettuce, etc.) in Asia and New Zealand in the future.	• Nil.	• Increased researcher capacity in analysis of sea freight supply chains. • Increased grower capacity in supplying vegetables through sea freight systems. • Increased income in regional Australia associated with a more profitable and sustainable vegetable industry.
Investment 4: Grains Storage Best Management Practice Investment 4: Grains Storage	• Increased price for some QLD and NSW pulse growers that store pulses before sale, due to application of new management strategies for reducing pest damage to stored mungbean and chickpea. • Increased use of storage for some QLD and NSW pulse growers who had not stored pulses previously, resulting in higher net returns. • Increased area of QLD and NSW pulses due to greater grower confidence in pulse storage management strategies. • A reduction in losses of value by pulse aggregators and exporters due to application of new management	• Nil.	• Increased capacity and capability of QLD researchers regarding grain storage strategies. • A potential increase in positive regional spillover impacts from future gains in productivity by some pulse growers and their supply chains in QLD.

Best Management Practice	strategies for reducing pest damage to stored mungbean and chickpea. • Higher quality of pulses produced in Queensland resulting in an increased demand and price from export markets.		
Investment 5: Mango Breeding Program (R2E2/Calypso)	• An increase in mango grower net profit with a partial shift from the Kensington Pride variety to the DAF-bred varieties (R2E2 and Calypso). Both varieties generate higher average saleable yields.	• Nil.	• Increased mango breeder capacity in selecting and delivering superior varieties. • Increased income in regional Australia associated with a more profitable and sustainable mango industry.
Investment 6: Building Capacity for Nursery Biosecurity Investment 6: Building Capacity for Nursery Biosecurity	• Increased productivity and profitability for some production nursery enterprises because of improved on-farm pest and disease management practices. • Increased productivity and profitability for some production nursery enterprises through improved use of pest and disease monitoring, diagnostics, and technical advice from government or other agencies. • Increased cost of production for some nursery enterprises through adoption of new and improved pest and disease management practices (e.g., additional monitoring or hygiene practices). • Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases.	• Some contribution to changes in chemical export off-farm through the use of pesticides. Some users may use less and/or more targeted pesticides, while some users may increase use of pesticides. Therefore, it is uncertain whether there would be a net positive or negative impact on the off-farm environment.	• Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management.

	• Reduced risk of the incursion and establishment of exotic pests and diseases through improved awareness and increased industry and government capacity to implement biosecurity plans and practices.		

Results

Aggregate investment criteria were estimated for the total aggregate investment and the DAF only aggregate investment. All benefit and cost cash flows were expressed in real 2021/22-dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022). All past and future benefit and cost cash flows were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. Each individual investment analysis ran for the length of the project investment period plus 30 years from the last year of the investment with the aggregate analysis running for 30 years from the last year of aggregate investment (2020/21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria by Investment

For each investment analysed, the estimated total present value of net benefits (PVB) and present value of RD&E investment costs (PVC) were used to estimate the net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), and MIRR. For further details on each investment, the impact assessment process, and analysis results, please refer the individual investment evaluation reports presented in Appendices A to F

Table 3 and Table 4 show the investment criteria estimated for each individual investment evaluated at 30 years after the last year of investment for the total investment and the DAF investment respectively. The present value of benefits (PVB) for the DAF investment in each analysis was estimated by multiplying the total PVB by the relative proportion of DAF investment in real, undiscounted dollar terms which varied from 43.4% (Investment 1) to 100% (Investment 4).

Table 3: Investment Criteria by Investment for the Total Investment
(30 years, 5% discount rate)

Investment	**PVB ($m)**	**PVC ($m)**	**NPV ($m)**	**BCR**	**IRR (%)**	**MIRR (%)**
Investment 1: Legume Learnings in the Coastal Landscape	11.54	5.24	6.30	2.20	6.7	7.5
Investment 2: Fish Attracting Structures	5.55	1.85	3.70	3.01	7.1	8.5
Investment 3: Vegetable Exports	1.06	0.38	0.68	2.80	7.3	8.0
Investment 4: Grains Storage Best Management Practice	15.22	1.24	13.98	12.30	31.3	13.6
Investment 5: Mango Breeding Program (R2E2/Calypso)	285.53	23.18	262.36	12.32	10.5	10.4
Investment 6: Building Capacity for Nursery Biosecurity	14.46	3.57	10.89	4.05	12.6	9.2
Aggregate[(a)]	**333.37**	**35.45**	**297.92**	**9.40**	**10.5**	**9.3**

(a) The aggregate figure may differ from the sum of the individual investment results because of small rounding discrepancies.

Table 4: Investment Criteria by Investment for the DAF Investment
(30 years, 5% discount rate)

Investment	PVB ($m)	PVC ($m)	NPV ($m)	BCR	IRR (%)	MIRR (%)
Investment 1: Legume Learnings in the Coastal Landscape	5.01	2.28	2.74	2.20	6.7	7.5
Investment 2: Fish Attracting Structures	4.19	1.40	2.79	3.00	7.0	8.4
Investment 3: Vegetable Exports	0.80	0.29	0.51	2.80	7.3	8.0
Investment 4: Grains Storage Best Management Practice	15.22	1.24	13.98	12.30	31.3	13.6
Investment 5: Mango Breeding Program (R2E2/Calypso)	199.88	18.15	181.73	11.01	9.4	10.0
Investment 6: Building Capacity for Nursery Biosecurity	8.50	2.10	6.40	4.05	12.6	9.2
Aggregate[(a)]	**233.60**	**25.45**	**208.16**	**9.18**	**9.4**	**9.0**

(a) The aggregate figure may differ from the sum of the individual investment results because of small rounding discrepancies.

Aggregate Investment Criteria

Table 5 and Table 6 show the aggregate investment criteria for different time periods up to 30 years from the last year of aggregate investment (2020/21) for the total investment and the DAF investment respectively. In the aggregate, the DAF investment made up approximately 63.1% of the real, undiscounted total investment costs.

Table 5: Aggregate Investment Criteria for the Total Investment
(All Six Investments, 5% Discount Rate)

Investment Criteria	Years from last year of investment						
	0	5	10	15	20	25	30
PVB ($m)	217.75	259.25	296.40	317.56	324.23	329.45	333.37
PVC ($m)	35.45	35.45	35.45	35.45	35.45	35.45	35.45
NPV ($m)	182.30	223.81	260.95	282.12	288.78	294.00	297.92
BCR	6.14	7.31	8.36	8.96	9.15	9.29	9.40
IRR (%)	10.2	10.4	10.5	10.5	10.5	10.5	10.5
MIRR (%)	11.2	11.0	10.7	10.4	10.0	9.6	9.3

Table 6: Aggregate Investment Criteria for the DAF Investment
(All Six Investments, 5% Discount Rate)

Investment Criteria	Years from last year of investment						
	0	5	10	15	20	25	30
PVB ($m)	152.24	180.93	206.97	221.99	226.87	230.68	233.60
PVC ($m)	25.45	25.45	25.45	25.45	25.45	25.45	25.45
NPV ($m)	126.79	155.48	181.52	196.54	201.42	205.24	208.16
BCR	5.98	7.11	8.13	8.72	8.91	9.06	9.18
IRR (%)	9.0	9.2	9.4	9.4	9.4	9.4	9.4
MIRR (%)	10.6	10.5	10.2	9.9	9.6	9.2	9.0

The annual undiscounted cash flows for the aggregate estimated total net benefits and aggregate total RD&E investment costs for the duration of the aggregate investment plus 30 years from the last year of investment are shown in Figure 1 below.

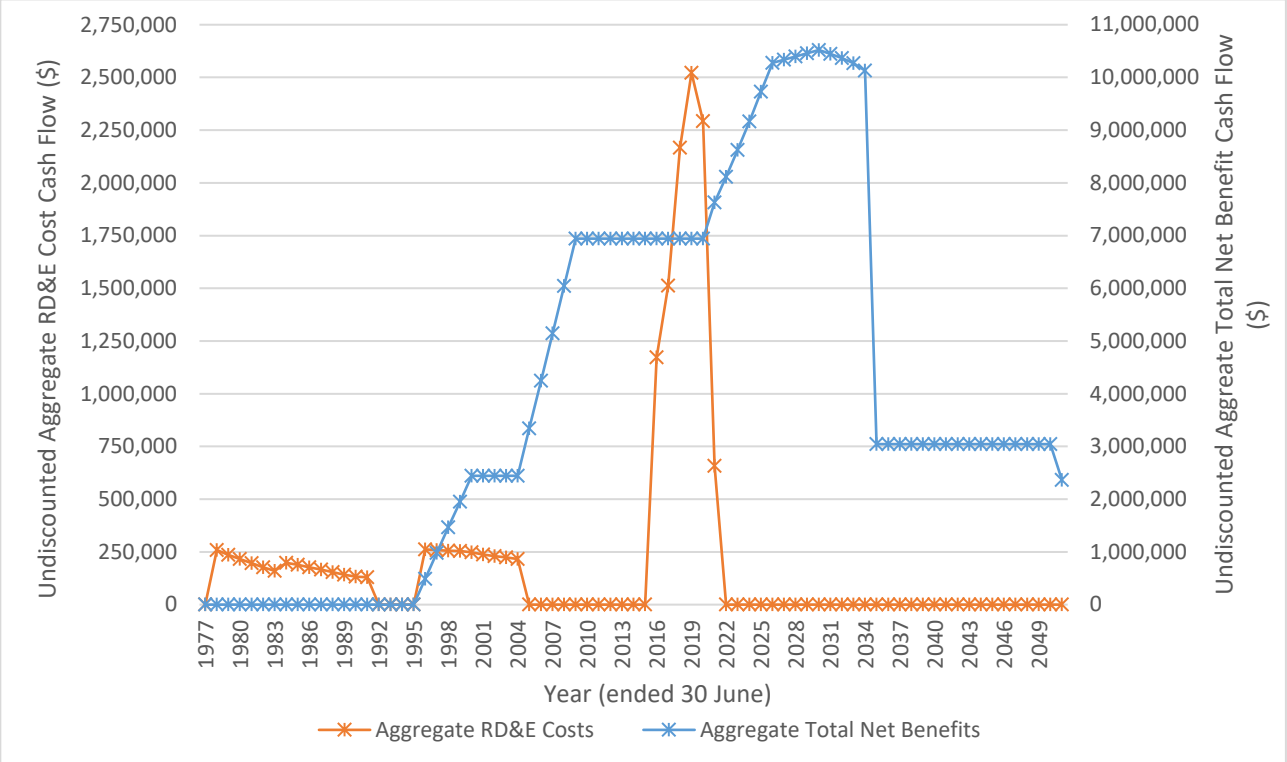

Figure 1: Annual Undiscounted Cash Flows for the Aggregate Estimated Total Net Benefits and Aggregate Total RD&E Investment Cost

Sources of Benefits

Table 7 shows the contribution of each individual investments' benefits to the aggregate PVB. The results reported suggest that the total expected net benefits from Investment 5 (Mango Breeding Program) at $285.53 million would have paid for the total aggregate RD&E investment costs of $35.45 million alone.

Table 7: Investment Level Benefit Contributions to the Aggregate PVB

Investment	**PVB ($m)**	**PVB as % of Aggregate PVB**
Investment 1: Legume Learnings in the Coastal Landscape	11.54	3.5%
Investment 2: Fish Attracting Structures	5.55	1.7%
Investment 3: Vegetable Exports	1.06	0.3%
Investment 4: Grains Storage Best Management Practice	15.22	4.6%
Investment 5: Mango Breeding Program (R2E2/Calypso)	285.53	85.7%
Investment 6: Building Capacity for Nursery Biosecurity	14.46	4.3%
Aggregate	**333.37**	**100.0%**

Discussion and Conclusions

The six DAF RD&E investments evaluated in the 2021/22 impact assessments (Appendices A to F) produced a range of economic, environmental, and social impact types. All six DAF RD&E investments analysed produced positive investment criteria at a 5% discount rate over 30 years. The net present value of the investments ranged from $0.68 million (Investment 3) to $262.36 million (Investment 5) and benefit-cost ratios ranged from 2.20 (Investment 1) to approximately 12.3 to 1 (Investment 4 and 5). Across all six investments, the projects contributed either directly or indirectly to all five of the current DAF Strategic Objectives described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022).

The total aggregate investment in all six RD&E investments was estimated at $35.45 million (present value terms) and produced aggregate total expected net benefits of approximately $333.36 million (present value terms). This gave an estimated aggregate net present value of $297.92 million, an aggregate benefit-cost ratio of 9.4 to 1, an aggregate internal rate of return of 10.5% and an aggregate MIRR of 9.3% (over 30 years, using a 5% discount rate and 5% reinvestment rate for the MIRR). The results were highly positive and suggest that, in the aggregate, the six selected investments evaluated performed above average given reported average benefit-cost ratios of between 4.5 and 5.5 to 1 for agricultural RD&E investments (Agtrans Research; AgEconPlus; and EconSearch, 2016; Agtrans Research, 2019).

The benefits estimated for Investment 5 (Mango Breeding Program) represented approximately 85.7% of the aggregate present value of benefits and could have paid for the total aggregate investment costs alone. However, any comparisons between the results for the individual investments should be made with some caution due to the uncertainties involved in some assumptions and the differing industries, types of research, and valuation frameworks used across the six individual evaluations.

Overall, the positive findings from the impact assessments of the six DAF RD&E investments should be viewed favourably by DAF, DAF funding partners, and industry stakeholders.

References

Agtrans Research. (2019). *Cross-RDC Impact Assessment 2019.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Agtrans Research; AgEconPlus; and EconSearch. (2016). *Cross-RDC Impact Assessment and Performance Reporting Update.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Australian Bureau of Statistics. (2022, March 02). *Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved January 2022, from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Queensland Government. (2021, June 30). *Strategic Plan.* Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/abd980b2-8b50-4024-8d13-f6b36316e101/daf-strategic-plan-2019-23-refreshed-updated.pdf?ETag=cfc88f3a81d8d2db2c185a5a2321b263

Queensland Government. (2022, June 28). *Strategic Plan 2021-2025.* Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Appendices

Appendix A: An Impact Assessment of Investment in Growers Solution Project: Coastal/Hinterland Queensland and NSW North Coast

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Lynda Bull, Executive Support Officer, Agri-Science Queensland, Department of Agriculture and Fisheries, Queensland

Angela Marshall, Agronomist, Sustainable Farming Systems, Crop and Food Science, Department of Agriculture and Fisheries, Queensland

Ian Dart, Productivity Improvement Manager, Bundaberg Sugar

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
CBA	Cost Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries, Queensland
DPI	Department of Primary Industries
GDP	Gross Domestic Product
GRDC	Grains Research and Development Corporation
MIRR	Modified Internal Rate of Return
N	Nitrogen
n.s.	No solution
NSW	New South Wales
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation

Executive Summary

This report presents the results of an impact assessment of a Queensland Department of Agriculture and Fisheries (DAF) investment in a project associated with improving regional production of grain legume crops in northern New South Wales (NSW) and Queensland (QLD). The project was funded by the Grains Research and Development Corporation (GRDC), DAF, NSW Department of Primary Industries (DPI) and CSIRO over the each of the five years ending June 2016 to June 2020.

The project is first described qualitatively using a logical framework that includes project objectives, activities and outputs, outcomes and impacts. Impacts were then categorised into a triple bottom line framework. Principal impacts were then valued.

The cost-benefit analysis was conducted according to the current Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018). Benefits were estimated for a range of time frames up to 30 years from the last year of investment (2019/20). Past and future cash flows in 2021/22 dollars were discounted to the year 2021/22 using a discount rate of 5% to estimate the investment criteria.

The large investment in this project and its associated outcomes to date, have been important in driving increased productivity and profitability of the QLD grain legume industry. The pathway to these impacts has been through an increase in legume area, yield and quality for some regional legume crop growers in NSW and QLD. In addition, the project has significantly impacted on sugarcane production through increasing productivity with optimal crop rotation practices.

Total funding from all sources over the project duration was approximately $4.11 million in nominal dollar terms ($5.24 million in present value terms). The value of total potential benefits due to the project were estimated at $11.54 million (present value terms). This result represented an estimated net present value of $6.30 million, a benefit-cost ratio of 2.2 to 1, an internal rate of return of 6.7% and a modified internal rate of return of 7.5%.

As there were several potential impacts identified that were not valued in monetary terms, it is likely that the investment criteria reported may be conservative and may have undervalued the full value of benefits delivered by the investment.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 1 (Legume Learnings in the Coastal Landscape). The investment was funded over the period July 2015 to June 2020 and titled: *Growers solution project for coastal/hinterland Queensland and NSW North Coast.*

Method

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

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

The GRDC Grower Solutions Project (2016-2020) was co-funded by the Grains Research and Development Corporation (GRDC), DAF and the New South Wales Department of Primary Industries (NSW DPI). The project addressed linkages between regional research and localised development resulting in fast tracking relevant outcomes to help growers and agronomists make improved decisions on farm, and encourage practice change that increases farm profitability.

The project targeted grain production regions in QLD and NSW where producers were largely small-scale producers of traditional grain crops and-legume grain crops (e.g. sorghum, wheat, soybean, peanut, mungbean) often grown as a rotation crop in another cropping system. The regions included the North Coast of NSW and three QLD regions (the Coastal Burnett, Inland Burnett and the Burdekin).

The growers in these regions have smaller sized farms than the traditional grain growing districts (for example the grain growers further west), however the climate and soil types are more productive so yields are often higher (Angela Marshall, pers. comm., May 2022). Also, farm sizes are smaller than further west because grains are not the dominant cropping system; for example, they are often just the fallow crop for the dominant sugarcane farming system, and individual sugarcane farm sizes are usually significantly smaller areas than wheat farms (Angela Marshall, pers. comm., May 2022).

Grain legumes were viewed as an additional source of income to that from mainstream crops, as well as providing positive soil nutrient impacts to subsequent sugarcane or cereal crops if included in a rotation.

Characteristics of the existing cropping systems in the four regions targeted included:

- North Coast of NSW: The major crop was sugarcane with a grain legume (soybean) often grown in rotation with the sugarcane.
- Coastal Burnet (Bundaberg, Childers and Maryborough): The major crop was sugarcane and it had been shown earlier that grain legumes grown in the sugarcane rotation could significantly increase sugarcane yields and reduce the nitrogen (N) requirement of the following sugarcane crops.
- Inland Burnet: A wide variety of mainstream crops was grown including winter cereals (e.g. wheat) and summer cereals (e.g. maize and sorghum crops). The grain legume crops grown included soybeans, mungbeans, navy beans and peanuts.
- Burdekin: With high levels of sunlight /radiation and water that were characteristic of the region, the major crop was sugarcane; the region was expected to increase its production of legume crops (mungbeans and soybeans) in the future.

The 2016-2000 Grower Solutions Project sought to identify and prioritise issues that were constraining grain legume production in each region, carry out activities such as field trials to address the key issues, extend the findings directly to grain legume growers, track practice change, and identify emerging research and development (R&D) issues for consideration of further investment. It should be noted that the GRDC Grower Solutions Project (2016-2020) was carried out at the same time as another DAF project co-funded by Sugar Research Australia. This parallel project focused on the grain legume cropping system benefits to the subsequent sugarcane crop.

Project Details

Summary

Project code: Not applicable

Title: *Growers solution project for coastal/hinterland Queensland and NSW North Coast*

Research Organisation: Department of Agriculture and Fisheries, Queensland

Project Supervisor: Neil Halpin, Senior Agronomist, Department of Agriculture and Fisheries, Queensland

Period of Funding: July 2015 to June 2020 (5 years)

Objective

The objective of the project was to improve the rate of industry adoption and uptake of improved practices and improve linkages between R&D agencies, growers, advisers and agribusiness in regions of QLD and NSW.

Logical Framework

Table A1: Logical Framework for Research, Development and Extension to support the Growers Solution Project for Coastal/Hinterland Queensland and NSW North Coast

Activities	<u>Steering Committee</u>
	• An overall Steering Committee for the project was established that included the GRDC Grower Relations Manager; this Committee integrated activities across the various regional nodes, ratified the annual work plans of the Regional Committees, and ensured coordination and focus and minimal duplication of issues across regions.
	
	<u>Regional Committees</u>
	• Regional Committees including grain growers, agronomists and agribusiness representatives were established to assist in defining regional priorities and developing annual work plans for each of the regional nodes.
	• The Regional Committees were established for the North Coast of NSW, Coastal Burnett, Inland Burnett, and the Burdekin.
	
	<u>Field Trials, Demonstrations, and Case Studies</u>
	• A series of field trials and demonstrations was established in each of the four regional nodes to explore a range of different issues and assist communication with growers and their advisers.
	• For example, in the first year, a peanut fungicide application trial was carried out in the Coastal Burnett region, as was a trial in the same region addressing whether row spacing and/or plant population impacted productivity of soybean under low or high irrigation input systems.
	• Another coastal Burnett trial evaluated the benefits from the application of sugar factory 'mill-mud' on the productivity of peanut cropping.
	• In NSW assessments were made on the use of mill ash and gypsum to improve soybean production on soils that were poorly structured.
	• A series of case studies were completed; subject matter included:
	  ○ Managing heavy clay soils
	  ○ Growing mungbeans in the farming systems of the Burdekin
	  ○ Application of mill-mud in the sugarcane/legume farming system
	  ○ Impact of traffic systems on soil structure and tillage costs in Kingaroy

	<u>Communication and Extension Activities</u> • Various field days, bus tours and workshops for growers were held across each of the regional nodes. • A number of grower practice change surveys were completed; these were conducted on an annual basis in each of the regions (Angela Marshall, pers. comm., May 2022). <u>Post Project Impact Survey</u> • A post-project Impact Survey was carried out by Coutts J&R in 2020.
Outputs	<u>Coordination and Integration</u> • The integrative activities of the Steering Committee and the Regional Committees ensured that the growers across the regional nodes were exposed to a complete and consistent framework of issues. • A Research and Extension Priority List and Action Plan for each of the four regions was developed and was regularly updated. <u>Field Trials, Demonstrations and Case Studies</u> • Delivery of research findings to growers on identified management priorities that could be used to facilitate practice change on farms. • The field trials, demonstrations, and case studies showed that significant increases in grain legume productivity as well as the productivity of associated rotation crops, were achievable via on-farm practice changes. <u>Grower Participation, Communication and Extension</u> • A total of 2,352 growers and agribusinesses attended the 68 project events over the period of the project. <u>Impact Survey</u> • Ninety-five interviews were completed of which 72% were growers. • Field days were reported as the most common engagement activity. • Respondents reported that new insights were gained regarding soil health, nutrition and fertiliser management, rotational legume crops, and herbicide and pesticide management, with most taking further action with advisers (94%), seeking further information from other sources (49%), and making a change in farm practice (42%). • Of the 95 interviewees, 40 reported a practice change with main benefits being improved productivity and profitability, improved soil and reduced input use and costs; of the few that were able to quantify the productivity gains, the range was 10-30%. • Given the positive results of the survey, the impact survey report concluded with three recommendations: (a) it makes sense to build on the relationships, expertise and successes, and continue into a further project phase. (b) continue the emphasis on trials and demonstrations linked to priority needs. (c) monitoring evaluation should be broadened in future phases to include follow up of participants from activities and undertake grower impact case studies. • There has been no direct follow-up to these recommendations after the project funding ceased; however, if and when funding becomes available, the intention is to involve the growers/agro communities in trial work (Angela Marshall, pers. comm., May 2022). • An ongoing activity being undertaken is to compile all the trial reports from the project and other information from the Coastal Burnett into a Field Trial Compendium; it is hoped that this will be available to provide to growers by the end of calendar 2022 (Angela Marshall, pers. comm., May 2022).

Actual and Expected Outcomes	• The impact survey reported that 60% of growers involved in the project made on-farm practice changes that could be attributed to the project activities. • These on-farm practice changes have facilitated an increase in the productivity of various grain legume crops across each of the four nodes. • Also, there has been an increase in the productivity or profitability of rotation crops (e.g. sugarcane and winter and summer cereals) via growers making more informed decisions, for example, on the amount of N required following a grain legume crop. • These changes also have contributed to growers achieving a reduction in environmental losses of N to off-farm locations. • The project also has encouraged the development of local communities of growers and agronomists who were able to network at the Growers Solutions events and who have maintained these relationships after the end of the project (Angela Marshall, pers. comm., May 2022).
Potential Impacts	• An increase in the profitability of production of various grain legume crops in the targeted regions. • Potential for an increased area of various grain legume crops. • An increase in the benefits to other crops in the rotation (e.g. sugarcane and winter and summer cereals). • Increased efficiency/effectiveness of future R&D resource allocation through identification and prioritisation of key industry issues and constraints. • Improved soil health. • Improved water quality downstream from farms reducing N export off-farm and hence the delivery of increased environmental sustainability.

Source: DAF project documentation and consultations with project and industry personnel.

Nominal Investment

Table A2 shows the total annual investment made by contributor in the project entitled Growers Solution Project for Coastal/Hinterland Queensland and NSW North Coast (DAQ00204).

Table A2: Total Investment in RD&E to Support the Growers Solution Project for Coastal /Hinterland Queensland and NSW North Coast (nominal dollar terms)

Year ended 30 June	GRDC ($)	DAF ($)	NSW DPI ($)	CSIRO ($)	Total ($)
2016	350,239	298,000	46,500	60,400	755,139
2017	357,992	306,600	49,400	62,200	776,192
2018	383,495	340,300	52,600	64,100	840,495
2019	377,754	354,800	56,000	66,000	854,554
2020	384,707	366,900	59,500	68,000	879,107
Totals	**1,854,187**	**1,666,600**	**264,000**	**320,700**	**4,105,487**

Source: DAF Project Agreement with GRDC

Management and Administration Costs

For the GRDC and DAF investment the management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table A2. The salary multiplier that was used for DAF salaries funded by GRDC was 1.85; for salaries funded by DAF the salary multiplier was 2.85 (Source: Project Agreement).

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022).

Impacts

Table A3 provides a summary of the principal types of potential impacts from the project titled Growers Solution Project for Coastal/hinterland Queensland and NSW North Coast. Impacts have been taken and potentially expanded from those listed in Table A1 and, using a triple bottom line framework, categorised into economic, environmental and social impact types.

Table A3: Principal Potential Impact Types from Investment in Project Titled Growers Solution Project for Coastal/hinterland Queensland and NSW North Coast

Economic	• Increased profitability of grain legume cropping industries in specified regions of QLD and Northern NSW. • Potential for increased area of various grain legume crops in each of the four nodes. • An increase in the benefits to other crops in the rotation (e.g. sugarcane and winter and summer cereals). • Increased efficiency/effectiveness of future R&D resource allocation through identification and prioritisation of key industry issues and constraints.
Environmental	• Improvement in soil health through increased adoption of legume crop rotations and reduced tillage. • Increased use of leguminous crops in rotations leading to reduced use of fertiliser N in some regional cropping systems (e.g. sugarcane), in turn leading to reduced export of mineralised N to waterways.
Social	• Increased capacity and capability of Queensland and northern NSW agronomists and extension personnel regarding grain legume production and crop rotational strategies. • A potential increase in positive regional spillover impacts from future gains in productivity and incomes in regional cropping systems in QLD and northern NSW.

Public versus Private Impacts

The principal private impact identified in this evaluation is directly related to increased productivity in the QLD and NSW regional cropping industries. The public impacts include a potential increase in the capacity and capability of some agronomists and extension officers, as well as some regional communities servicing the cropping industries and their supply chains.

Distribution of Private Impacts

The increase in cropping profitability of grain legumes will directly accrue to some QLD and NSW cropping enterprises in the various targeted regions. However, such private benefits will be shared by these enterprises and their supply chains, according to associated supply and demand elasticities.

Impacts on Other Australian Industries

There may be some spillover impacts on grain legume growers in some of the non-target regions of Australia, although these are expected to be minor.

Impacts Overseas

There are unlikely to be any significant impacts to overseas parties.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table A4. The project addressed in the current evaluation has contributed to National Science and Research Priority 1 (optimising agricultural productivity). Further, the research, development and extension (RD&E) investment is likely to contribute in part to National Agricultural Innovation Priority 1 (Australia is a trusted exporter of premium food and agricultural products by 2030) by maintaining or increasing its security of exports of some grain legumes.

Table A4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030 **2.** Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 **4.** Australia is a mature adopter, developer and exporter of digital agriculture by 2030 Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation and decision making around QLD's future investment are reproduced in Table A5.

The investment addressed QLD Agricultural RD&E Strategy 2 (Identify and promote agriculture and food RD&E opportunities) as well as RD&E Strategy 3 (Support existing sector to grow and develop new business). In terms of Investment Decision Rule Guides, the project addressed Decision Rule Guide 1, a Real Future Impact.

Table A5: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The investment in the Legume Growers Solutions project has contributed to DAF Strategic Objectives 1 and 2, with some contribution to Strategic Objective 5.

Case Study

The following section provides a real-world example of how the outputs of the Growers Solutions investment, completed by DAF, have been adopted/implemented and demonstrates how industry are benefitting from the investment.

Case Study 1: Increasing productivity with optimal crop rotation practices

An interview was conducted with Ian Dart who currently holds the position of Productivity Manager (Farms) for Bundaberg Sugar. Ian provided the following comments:

"I was recently involved in a project funded by the Queensland Department of Agriculture and Fisheries (DAF) entitled "*Growers solution project for coastal/hinterland Queensland and NSW North Coast*". My involvement in the project was on behalf of Bundaberg Sugar who operate about 8,500 ha of sugarcane in the vicinity of Bundaberg. We grow the sugarcane in rotation with soybeans and peanuts."

"The experience we have gained from the DAF project has provided significant knowledge as to how Bundaberg Sugar can improve its grain legume productivity in relation to the farming practices we use in crop rotation, for example, soybean crops with sugarcane. As a result of the project:

- We have made significant agronomic changes such as row spacing and population densities for soybean production,
- We have commenced using specialised minimum tillage equipment, and
- We have continued with the application of mill mud to our cropping areas."

"The above changes have improved the productivity of the rotation and, while there have been some cost increases, these have been significantly outweighed by the increased productivity and profitability gains we have experienced. As Bundaberg Sugar has a large land area of sugarcane grown in rotation with soybean, our engagement with project has been most rewarding."

Valuation of Impacts

Impact Valued

The impact valued was an increase in the profitability of grain legume production in the targeted regions.

Valuation of Impact: Increased profitability of grain legume production

Estimates of Existing Areas of Legume Crops by Region

Northern NSW:

The principal crop grown is sugarcane with the principal legume crop being soybean grown in rotation with the sugarcane crop.

Coastal Burnett including Bundaberg, Childers and Maryborough:

The principal crop grown is sugarcane with the principal legume crop being soybeans and/or peanuts grown in rotation with sugarcane.

Inland Burnett:

The principal crops grown are winter and summer cereals (e.g. wheat, maize and sorghum) with various legumes such as soybeans, navy beans, and peanuts grown in rotation with the cereal crop.

North QLD Townsville:

The principal crop grown is sugarcane with the principal legume crops being mungbeans and soybeans.

Table A6 provides a summary of the areas of legume crops grown in each of the project target regions in 2019/20.

Table A6: Assumed Areas of Legume Grain Crops in Target Regions in 1999/2020

Target region	Principal grain legume crops included	Annual area of principal grain legume crop(s) (ha)
Northern NSW	Soybeans	3,250
Coastal Burnett	Soybeans and peanuts	3,293
Inland Burnett	Soybeans, navy beans and peanuts	15,094
North QLD	Soybeans and mungbeans	998

Source: ABS (2020)

Chickpeas were excluded from the principal grain legume crops in Table A6, as chickpeas were not targeted in the project.

Estimates of Gross Margins of Representative Grain Legume Crops by Region

Estimates of average gross margins for representative grain legume crops by region are provided In Table A7.

Table A7: Estimates of Gross Margins for Representative Grain Legume Crops

Target region	Representative grain legume crop assumed	Gross margin ($/ha)
Northern NSW	Soybean (rainfed)	383 (a)
Coastal Burnett	Soybean (rainfed and irrigated)	649 (b)
Inland Burnett	Soybean (rainfed)	649 (c)
North QLD	Soybean (irrigated)	837 (d)

(a) $320 per ha (2012/13 dollar terms) converted to 2021/22 dollar terms via a multiplier of 1.1957 (Source: NSW Department of Primary Industries).
(b) $649 per ha (simple average of $647 per ha for South Burnett and $653 per ha for North Burnett (Source: AgMargins, DAF); in the interests of being conservative, the rainfed gross margin for soybean has been used instead of soybean irrigated and/or peanuts.
(c) $649 per ha (simple average of $647 per ha for South Burnett and $653 per ha for North Burnett) (Source: AgMargins, DAF); in the interests of being conservative, the rainfed gross margin for soybean has been used instead or soybean irrigated and/or peanuts.
(d) $837 per ha Based on assumptions for irrigated soybean in three other regions.

Impacts Not Valued

The three other potential economic impacts identified in Table A3 that were not valued included the following:

- Potential for an increased area of various grain legume crops in each of the four nodes.
- An increase in the benefits to other crops in the rotation (e.g. sugarcane and winter and summer cereals).
- Increased efficiency/effectiveness of future R&D resource allocation through identification and prioritisation of key industry issues and constraints.

First, any increase in regional grain legume areas due to the project were not valued due to the limited area data available since the project finished only in 2020.

Second, the increase in benefits to other crops in the rotation (e.g. saved nitrogen fertiliser) was not valued due to the difficulty of making reasonable assumptions. Further, as reported in the earlier background section, another project funded by Sugar Research Australia and DAF was aimed at capturing whole farm system benefits from grain legume cropping system benefits to the subsequent sugarcane crop.

Third, the improved efficiency/effectiveness of future R&D investment was not valued due to the difficulty of ascertaining appropriate assumptions.

No attempt was made to value the environmental impacts identified in Table A3 (improved soil health and reduced export of mineralised N to off-farm waterways) due to lack of available information in the various regional areas as well as limited time and resources.

The two social impacts identified in Table A3 that were not valued are listed below, together with the associated reasons for non-valuation:

- Increased capacity and capability of QLD and northern NSW agronomists and extension personnel regarding grain legume production and crop rotational strategies; this potential impact was not valued explicitly as, to a large extent, it was captured in the economic impact that was valued.
- A potential increase in positive regional spillover impacts from future gains in productivity and incomes in regional cropping systems in QLD and northern NSW; this impact was not valued as the spillovers would be difficult to value given the given the number and diversity of targeted regions involved with grain legume production in the project.

Summary of Assumptions

Specific assumptions made for the valuation of the impact are provided in Table A8. A number of the assumptions involved some uncertainty, so that some degree of conservatism was effected when finalising the assumptions for valuing the impact.

Table A8: Summary of Assumptions

Variable	Assumption	Source
Areas of grain legumes in target regions	See Table A6	ABS (2020)
Gross margins of grain legumes in target regions	See Table A7	Various
Proportion of grain legume area in target regions where some improvements were made due to the project	30%	Agtrans Research
Assumed increase in gross margins in all target regions due to project	20%	
Year of first impact	2020/21	
Risk factors and counterfactual		
Probability of outputs	100%	Agtrans Research
Probability of outcomes occurring	90%	
Probability of impacts occurring given successful outcomes	90%	
Counterfactual	Impacts assumed would not have occurred without the project funding	

Results

All benefits were expressed in 2021/22 $ terms. All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2019/20) to the final year of benefits assumed.

Investment Criteria

Tables A9 and A10 show the investment criteria estimated for different periods of benefits for the total investment and DAF investment respectively.

Table A9: Investment Criteria for Total Investment in the Grower Solutions Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	3.25	5.80	7.79	9.36	10.58	11.54
Present value of costs ($m)	5.24	5.24	5.24	5.24	5.24	5.24	5.24
Net present value ($m)	-5.24	-1.99	0.56	2.55	4.12	5.34	6.30
Benefit-cost ratio	0.00	0.62	1.11	1.49	1.79	2.02	2.20
Internal rate of return (%)	negative	negative	1.4	4.6	5.9	6.5	6.7
MIRR (%)	n.s.	negative	5.8	7.2	7.6	7.6	7.5

n.s. no solution

Table A10: Investment Criteria for DAF Investment in the Grower Solutions Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	1.41	2.52	3.39	4.06	4.60	5.01
Present value of costs ($m)	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Net present value ($m)	-2.28	-0.86	0.24	1.11	1.79	2.32	2.74
Benefit-cost ratio	0.00	0.62	1.11	1.49	1.79	2.02	2.20
Internal rate of return (%)	negative	negative	1.4	4.6	5.9	6.5	6.7
MIRR (%)	n.s.	negative	5.8	7.2	7.6	7.6	7.5

n.s. no solution

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of investment are shown in Figure A1.

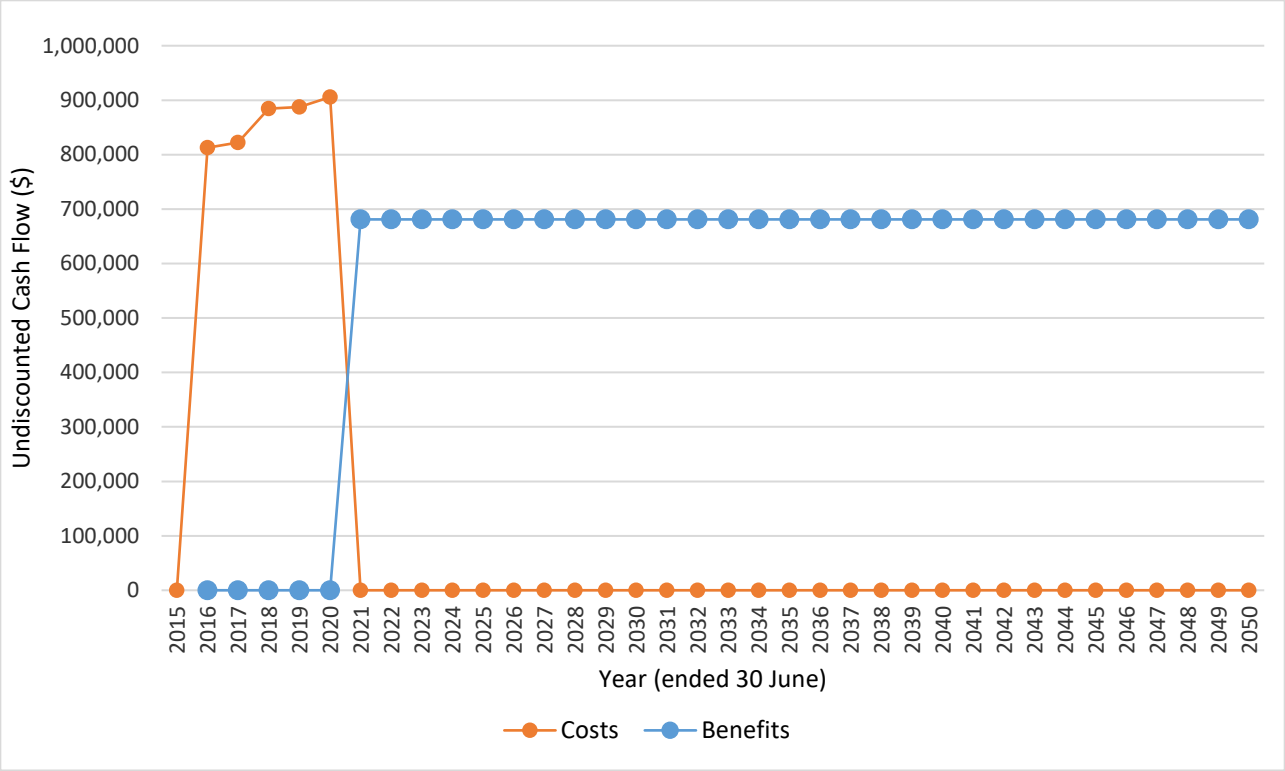

Figure A1: Annual Cash Flow of Undiscounted Total Benefits and Total Costs

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table A11 presents the results that showed a moderate sensitivity to the discount rate, largely due to the relatively long period of benefits assumed.

Table A11: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	20.43	11.54	7.77
Present value of costs ($m)	4.31	5.24	6.34
Net present value ($m)	16.12	6.30	1.43
Benefit-cost ratio	4.74	2.20	1.23

A sensitivity analysis also was carried out on the assumption regarding the proportion of the grain legume area in target regions where improvements were made due to the project. Results are reported in Table A12. The assumption regarding the implementation level could fall from 30% to 14% for the project benefits to still cover the investment costs, with all other assumptions remaining the same.

Table A12: Sensitivity to Assumed Area of Improved Grain Legume Area Due to the Project Investment (Total investment, 30 years)

Investment Criteria	**Level of implementation Assumed**		
	20%	**30% (Base)**	**40%**
Present value of benefits ($m)	7.69	11.54	15.39
Present value of costs ($m)	5.24	5.24	5.24
Net present value ($m)	2.46	6.30	10.15
Benefit-cost ratio	1.47	2.20	2.94

Confidence Ratings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made for the benefit valued, including the linkage between the research and the assumed outcomes and impacts.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table A13). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table A13: Confidence in Analysis of Project

Coverage of Benefits	**Confidence in Assumptions**
Medium	Medium

Coverage of benefits was assessed as Medium. While there were several other potential benefits identified but not valued, the principal targeted economic impact from the project was valued.

Confidence in assumptions for the valuation was rated as Medium as some of the assumptions associated with the likely gains to the grain legume industry were somewhat uncertain.

Discussion and Conclusions

The foregoing assessment presents the results of an analysis of an investment in a project associated with identification and extension of management priorities that could be used to facilitate practice change on farms producing various grain legumes. An earlier impact survey associated with the project reported that 60% of growers involved in the project made an on-farm practice changes.

The assessment describes the projects in a logical framework that included project objectives, activities and outputs, outcomes and impacts. Impacts were then categorised into a triple bottom line framework. One of the impacts was then subjected to an impact valuation process.

Given the assumptions made, the resulting investment criteria showed a moderate return on the investment. The total investment in the project of $5.24 million (present value terms) has been estimated to produce total gross benefits of $11.54 million (present value terms) and provided a net present value of $6.30 million, a benefit-cost ratio of 2.2 to 1 (using a 5% discount rate), an internal rate of return of 6.7% and a modified internal rate of return of 7.5%.

The investment criteria reported may have undervalued the full set of impacts delivered by the investment. The non-valued impacts included several other industry economic benefits; also, some environmental and social benefits were identified but not valued in the economic valuation

References

Agmargins, Queensland Department of Agriculture and Fisheries. Retrieved May 2022 at: https://agmargins.net.au/Reports/Index#

Australian Bureau of Statistics, (2020), Agricultural Commodities, Australia–2019-20. Retrieved from Australian Bureau of Statistics at: https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release#cereal-and-other-broadacre-crops

Australian Bureau of Statistics. (2022, March 02). Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from Australian Bureau of Statistics at: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Australian Bureau of Statistics. (2020), Agricultural Commodities, Australia–2019-20. Retrieved from Australian Bureau of Statistics at: https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release#cereal-and-other-broadacre-crops

Coutts J&R (2020) GRDC Coastal Grower Solutions Project: Impact Survey.

Queensland Government. (2022, June 28). Strategic Plan 2021-2025. Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Appendix B: An Impact Assessment of Investment in Research, Development and Extension on Freshwater Fish Attracting Structures

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Andrew Norris, Senior Fisheries Biologist, Queensland Department of Agriculture and Fisheries

Peter Taylor, President, Toowoomba and District Fish Stocking Association

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
FAS	Fish Attracting Structures
FRDC	Fisheries Research and Development Corporation
MIRR	Modified Internal Rate of Return
PVB	Present Value of Benefits
QLD	Queensland
RD&E	Research, Development, and Extension
RDC	Research and Development Corporation

Executive Summary

This report presents the assessment process, analysis, and associated findings of an impact assessment of a Department of Agriculture and Fisheries Queensland (DAF) investment in research, development, and extension (RD&E) associated with freshwater fish attracting structures (FAS) in Cressbrook Dam and Kinchant Dam funded over the period August 2017 to November 2020.

The impact assessment followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations (RDCs), Cooperative Research Centres, State Departments of Agriculture, and some universities. The evaluation process followed an input to impact continuum and involved both qualitative and quantitative analysis components. The impact assessment approach used was in accord with the current guidelines of the Council of Rural RDCs.

The investment in FAS RD&E at the Cressbrook and Kinchant Dams provided evidence that FAS positively affect fish abundance and aggregation and can be used to improve the fishing opportunities and experience for anglers in regional impoundments. Construction and deployment of FAS in regional Queensland (QLD) impoundments was also shown to be a potentially useful tool for regional fisheries managers, in conjunction with stocking and harvest restrictions, to improve recreational fishing opportunities and the value of regional impoundment fisheries to local communities.

Since completion of the projects, there has been significant interest in the implementation of FAS from anglers and stocking groups. Major waterway operators in QLD also have received multiple enquiries from stocking groups wishing to install FAS. Although no additional FAS projects have yet commenced, and policy relating to the use of FAS in QLD impoundments is still being developed, it is expected that the use of FAS in impoundment fisheries will be encouraged following the development of appropriate guidelines.

The investment in FAS RD&E has led to a number of potential positive impacts. The primary potential impact of the investment is increased future income for tourism related businesses in regional communities where FAS are constructed and installed because of a sustainable increase in the flow of intra-state and inter-state regional angling tourists. Further, though there are some additional costs incurred by stocking groups, regional councils or others installing FAS, the investment in FAS has contributed to improved recreational amenity for local anglers as well as intra-/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed.

The total investment in the two FAS RD&E projects was estimated at $1.85 million (present value terms) and produced total expected net benefits of approximately $5.55 million (present value terms). This gave an estimated net present value of $3.70 million, a benefit-cost ratio of 3.0 to 1, an internal rate of return of 7.1% and a MIRR of 8.5% (over 30 years, using a 5% discount rate and 5% reinvestment rate for the MIRR).

Overall, the assessment of DAF investment in the FAS RD&E found that the projects produced useful outputs that were well received by end-users and other stakeholders. Also, the projects have, and are likely to, deliver positive impacts for regional QLD communities, impoundment anglers, and the broader Australian community. The investment should be viewed favourably by DAF, DAF funding partners, and fishing industry stakeholders.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 2 (Fish Attracting Structures). The investment included a two related RD&E projects associated with freshwater fish attracting structures (FAS) in the Cressbrook and Kinchant Dams funded over the period August 2017 to November 2020.

Method

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

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

Several regional councils in QLD had identified inter- and intra-state tourism as a way to help generate business opportunities in their communities. Recreation fishing was identified as one method of attracting visitors to regional areas. Many regional areas have stocked impoundment fisheries, but most dams have limited amounts of high-quality fish habitat and often fish are concentrated around the dam walls where rocky habitats aggregate fish. However, anglers typically are prohibited from fishing within close proximity to dam walls for safety and infrastructure protection reasons. Access for shore-based anglers generally is restricted to small areas and, consequently, catch rates are often poor. Boat anglers also often need to cover extensive ground to locate fish and may not be able to target fish if they are aggregating in closed areas.

It had been noted that many dams in the United States of America had undergone strategic fish habitat enhancement using FAS that had positively influenced impoundment fisheries and contributed to significant increases in the number of angling tourists visiting or utilising these impoundments with positive flow-on socio-economic benefits. To improve the quality of fishing and attract a sustained inflow of anglers to regional impoundments in QLD, DAF funded two related FAS research projects in conjunction with the Fisheries Research and Development Corporation (FRDC), Toowoomba and District Fish Stocking Association and Mackay Regional Council to investigate and evaluate the installation of FAS in regional QLD impoundments.

Project Details

Summary

Project Code(s):

a) FRDC Project 2017-019 (DAF Agreement: AS10640.01)
b) No code (DAF Agreement AS10697.01)

Title(s):

a) *Freshwater fish attracting structures (FAS): Evaluating a new tool to improve fishing quality and access to fisheries resources in Australian Impoundments*
b) *Kinchant Dam fish habitat enhancement project*

Research Organisation(s):

a) Department of Agriculture and Fisheries Queensland
b) Department of Agriculture and Fisheries Queensland

Principal Investigator(s):

a) Andrew Norris, Senior Fisheries Biologist, DAF
b) David Nixon, Research Scientist, DAF

Period of Funding:

a) August 2017 to November 2020
b) March 2018 to August 2020

Objectives

Project 1: Cressbrook Dam

The specific objectives of the project were:

1. Evaluation of the ability of several types of fish attracting structures (FAS) to attract a range of native fish species in impoundments.
2. Evaluation of the impacts of FAS on angler catch rates and angler satisfaction rates.
3. Evaluation of the impact of FAS on angler visitation rates.
4. Development of best practice guidelines for the installation of FAS in Australian impoundments.

Project 2: Kinchant Dam

The goal of Project 2 was to install FAS capable of significantly improving productivity, carrying capacity, growth rates and stocked fish survival within the Kinchant Dam catchment. Specific objectives of the project were:

1. Develop a habitat enhancement plan for Kinchant Dam, to improve recreational fishing quality in the dam and attract more tourist anglers to the region.
2. Train community members in habitat construction and deployment.
3. Commence habitat deployment.

Logical Frameworks

Each project investment was described in a logical framework that summarised key activities, outputs, outcomes, and impacts. Table B1 and Table B2 present the logical framework for the Cressbrook Dam project and the Kinchant Dam project respectively.

Table B1: Logical Framework for FRDC Project 2017-019: Cressbrook Dam

Activities	• Baseline surveys and stakeholder engagement were used to develop a fish attraction plan for Cressbrook Dam. • The plan outlined the type, number, and location of FAS to be installed and defined fixed monitoring sites. • A combination of methods was employed to generate multiple lines of evidence and provide a clear picture of the responses to FAS installation. • Monitoring was ongoing throughout the project to evaluate trends pre-, during and post-FAS installation. • A total of 576 FAS were installed across 25 sites between February 2019 and January 2020. The FAS comprised 182 synthetic spiders, 142 synthetic trees, 130 brush bundles, 44 Georgia cubes, 39 timber cribs, 26 suspended FAS and 13 branch bundles. • The FAS were constructed in conjunction with volunteers from the Toowoomba and District Fish Stocking Association and the general community. • The influence of FAS installation on fish distributions was assessed via twice yearly electrofishing surveys, quarterly targeted angling surveys, and acoustic telemetry. The acoustic telemetry tracked the fine-scale movements of 30 Australian Bass and 30 Golden Perch for a period of 2 years. • FAS condition and their use by fish were monitored using sonar after poor underwater visibility restricted the value of underwater video footage from a drone or fixed cameras. • Creel surveys and counts of boat visitation were also used to collect information on visitation rates, angler effort, catch rates, knowledge of the project, and use of FAS by anglers. • A set of best practice guidelines for FAS construction and installation was developed. • Presentations on the potential opportunities and benefits of using fish attraction structures in impoundments were given to: • Toowoomba Regional Council • Brisbane Valley Anglers • Somerset and Wivenhoe Fish Stocking Association • Pine Rivers Fish Management Association • Mackay Area Fish Stocking Association • Mackay Regional Council • Rockhampton Regional Council • Victorian Fisheries Authority, VRFish, stocking groups and anglers at Codfest 2017 • State-wide fish stocking groups at the state-wide fish-stocking workshop, Warwick, 4th November 2018. The presentation at this workshop also outlined the Cressbrook Dam FAS project. • A presentation was also made at the Reservoir Fisheries Habitat Partnership conference held in Kansas City, Missouri, USA.

Outputs	• The results of the study indicated that a range of native Australian fish species responded to the installation of FAS. • The primary species targeted by anglers in Cressbrook Dam (Golden Perch and Australian Bass) were both observed to use the installed FAS. • Smaller prey species were also commonly detected around the FAS, but the pre- to post-FAS installation trends were less clear due to significant general increases in abundance occurring across the entire impoundment. • Monitoring indicated the localised abundance of Australian Bass and Golden Perch increased around all FAS types following their installation. However, the observed trends varied between monitoring techniques. • All FAS types retained their structural integrity for the duration of the study, with no degradation evident. Unfortunately, the period of monitoring was insufficient to assess long term durability, but all FAS types tested appear suitable for use in other impoundments. • Targeted angling surveys suggested that catch rates were moving in a positive direction, but the results were limited by very low catch rates and the observed trends were generally not statistically significant. Catch rates increased at synthetic and timber FAS sites whilst decreases were observed at the Control sites. • The creel survey results showed an overall trend towards improving angler attitudes to fishing in Cressbrook Dam and an improved perception of fishing quality post-installation of FAS. • The creel surveys also demonstrated trends for improvements in fish capture rates and angler success rates, following installation of FAS. • Among the anglers interviewed the median frequency of visitation to the dam increased three-fold from the pre- to the post-FAS installation periods. This provided evidence that installation of FAS improved the attractiveness of the fishery in Cressbrook Dam. • However, the study was hampered by falling water levels, frequent lengthy dam closures, a major bushfire and the global COVID-19 pandemic, all of which may have impacted on angler confidence to visit the dam and contributed to reduced sampling power. • Boat arrivals did not increase post-installation of FAS but remained relatively stable. • Post-closure of the dam due to blue green algae blooms, bushfires and Covid 19, it appeared that most of the visitation was by people from the Toowoomba region. However, the fact that boat arrivals remained reasonably steady, despite multiple closures and other external issues, suggested that it was plausible that boat arrivals would increase when the dam refilled and when effective promotion of the FAS was implemented. • The results from the study indicated that installing FAS into impoundments may provide an additional tool for fisheries managers, to be used in conjunction with stocking and harvest restrictions, to improve recreational fishing opportunities and the value of regional impoundment fisheries to local communities. • Also, a set of best practice guidelines for FAS construction and installation was produced to enable adoption of FAS by community groups such as fishing and stocking clubs.

Actual and Expected Outcomes	• Currently, management in Australia focusses on stocking and harvest control (through size and bag limits) to regulate impoundment fisheries. The results from Project 2017-091 indicated that installing fish attracting structures into impoundments may provide an additional tool for fisheries managers to improve the recreational fishing opportunities and the value of these fisheries to local communities. • The use of FAS in impoundments should be broadly applicable across Australia because many impoundments suffer from limited structural habitat complexity and most stocked fish species also show a high affinity for structural habitat and are expected to respond well to FAS installation. • A decision was made during the project to limit expansion of FAS use into additional dams until the results from this study and the other in the pilot program were finalised and guidelines on their use produced (Andrew Norris, pers. comm., 2022). • There was significant interest from both anglers and other stocking groups wanting to install FAS in other stocked impoundments. The major waterway operators in Queensland (Sunwater and Seqwater) have also received multiple enquiries from stocking groups wishing to install FAS (Andrew Norris, pers. comm., 2022). • However, no new FAS projects have yet commenced and policy relating to the use of FAS in QLD impoundments still is being developed and will be informed by the results from this project. • It is expected that the use of FAS in impoundment fisheries will be encouraged following the development of appropriate guidelines and policy and following presentation of the project's findings at the biannual QLD fish stocking workshop in due to be held in October 2022 (Andrew Norris, pers. comm., 2022). • It is expected that FAS will start to be constructed and installed by regional community groups (such as fishing and stocking clubs) and local councils in other regional impoundments in QLD and other areas of Australia.
Potential Impacts	• The primary impact of the investment in Project 2017-019 was increased future income for tourism related businesses in regional communities where FAS are constructed and installed to increase the in-flow of intra-state and inter-state regional angling tourists. • Further, to drive increased tourism flows, the investment in FAS has improved recreational amenity for local anglers and intra-state/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed. • The implementation of FAS may result in some increased costs for community groups, such as fishing and stocking clubs, or regional councils for construction, installation, promotion, and monitoring of FAS in regional impoundments.

Source: DAF project documentation and consultation with project personnel.

Table B2: Logical Framework for Kinchant Dam FAS Project

Activities	• Information from baseline surveys of the existing habitat and fish distributions, and community consultation were collected and combined to develop a fish attraction plan (FAP) for Kinchant Dam. • The FAP outlined the number, types and locations of FAS to be installed and how they would be monitored. • It was recommended that FAS clusters be installed at 36 sites around Kinchant Dam. • A total of 197 FAS were constructed and deployed, comprising of 88 synthetic trees, 39 pipe bundles, 30 synthetic hedges, 23 Georgia cubes, 14 Kinchant cribs and 3 suspended FAS. • All materials used to construct the FAS were durable and inert to ensure no detrimental impacts on the aquatic environment. The FAS types were also relatively snag-free, meaning anglers could fish right in amongst the habitat with less fear of losing gear. • To minimise the risk of FAS becoming overgrown by aquatic vegetation or being a risk to water-skiers and boats at low water levels, FAS all were placed in water deeper than 3 meters based on the 90th percentile for dam water levels. • The majority of FAS were constructed by community volunteers over the course of five working bees held on weekends. Additional FAS were also constructed by community groups in between the working bees. • Deployment of structures commenced in conjunction with a media launch day held on the 10th of November 2018. • A small barge was chartered to enable larger structures to be loaded and easily deployed. All large FAS were deployed using the barge, with a number of synthetic trees and the suspended FAS deployed using a smaller DAF vessel. • Deployment continued throughout the summer and autumn of 2019 and was completed by the end of May 2019. • Twice yearly boat electrofishing surveys (summer and winter) were used to monitor the response of fish to the installation of FAS and understand potential seasonal differences in habitat use. • Monitoring sites were spread across four broad habitat categories: vegetated margins, open water, around dam infrastructure, and where FAS were installed. For the analysis, the data were divided into two depth groups (shallow and deep) to counter the decline in electrofishing efficiency beyond 5 meter water depth. • Sonar imaging was used to assess the condition of the FAS and abundance of fish in their vicinity. • The Kinchant Dam Habitat Enhancement Project generated significant community and media interest. Stories were produced in newspapers, radio, fishing magazines, regional tourism guides, newsletters, podcasts and on multiple websites. • Project signage was installed at the boat ramp and the coordinates of the FAS are available in several websites and brochures.
Outputs	• Following installation, the catch rates for barramundi at FAS sites did not differ significantly to those around existing dam infrastructure and at vegetated sites. • This indicates the FAS were effectively attracting barramundi in similar proportions to the better-quality existing habitat in the dam. These three habitat types all had significantly higher catch rates than open water sites.

	• Catch rates almost tripled at intervention sites once FAS were installed. Even at deeper water sites, where electrofishing was less efficient, barramundi were significantly more likely to be captured where FAS had been installed compared with the control open water sites. • Bony bream and fly-specked hardyhead were the most abundant prey species observed in the electrofishing surveys. These species were both attracted to FAS sites. • Barramundi were frequently caught in close proximity to schools of bony bream and thus the bony bream around the FAS would likely help attract barramundi to those areas.
Actual and Expected Outcomes	• The installation of the FAS into Kinchant Dam has provided anglers with alternative habitat and areas to target fish. The FAS offer anglers the chance to target barramundi without having to fish the vegetated margins or closed zones around infrastructure in the dam. Installing the FAS beyond the weed-line means anglers can more readily troll or cast lures with less fear of snagging on aquatic vegetation. • These factors have made fishing at Kinchant Dam a more attractive proposition and are likely to encourage more anglers to visit the Mackay region as a premier fishing destination. • The project team recommended a follow-up project to value-add to the habitat enhancement project and keep Kinchant Dam in the media and tourism spotlight. The follow up project would be aimed at acoustically track fish use of FAS and habitat within Kinchant Dam. This would provide anglers detailed information on when and where to fish.
Potential Impacts	• Increased future income for tourism related businesses in regional communities where FAS are constructed and installed to increase the in-flow of intra-state and inter-state regional angling tourists. • Improved recreational amenity for local anglers and intra-state/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed. • The implementation of FAS may result in some increased costs for community groups, such as fishing and stocking clubs, or regional councils for construction, installation, promotion, and monitoring of FAS in regional impoundments.

Source: DAF project documentation and consultation with project personnel.

Nominal Investment

Table B3 (below) shows the total annual investment made in by DAF and other contributors in the Cressbrook Dam and Kinchant Dam FAS research. Other contributors included FRDC, the Toowoomba and District Fish Stocking Association and Mackay Regional Council.

Table B3: Total Investment in FAS RD&E (Two Projects)
(Nominal Investment)

Year ended 30 June	DAF ($)	Others ($)	Total ($)
2018	130,101	77,483	207,584
2019	119,029	97,044	216,073
2020	130,115	97,912	228,027
2021	7,250	44,102	51,352
Totals	**386,495**	**316,541**	**703,036**

Source: Project agreement and variations

Management and Administration Costs

For the DAF investment the management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table B3. The salary multiplier that had been used by DAF was a 2.85 multiplier for salaries contributed by DAF (Wayne Hall, pers. comm., 2017).

For the FRDC investment (included in 'Others'), the cost of managing the FRDC funding was added to the FRDC contribution for the project via a management cost multiplier (1.179). This multiplier was estimated based on a five-year average of the ratio of total FRDC cash expenditure to project expenditure reported in the FRDC's Cash Flow Statement (FRDC Annual Reports, 2017-2021). For other contributors a multiplier of 1.0 was applied assuming that management and administration were already included in the cost data provided.

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (Australian Bureau of Statistics (ABS), 2022).

Impacts

Table B4 provides a summary of the principal types of potential impacts from the FAS RD&E investment. Impacts have been taken and consolidated from those listed in Table B1 and B2 and categorised using a triple bottom line framework into economic, environmental, and social impact types.

Table B4: Principal Potential Impact Types from Investment in FAS RD&E

Economic	• Increased future income for tourism related businesses in regional communities where FAS are constructed and installed to increase the in-flow of intra-state and inter-state regional angling tourists. • The implementation of FAS may result in some increased costs for community groups, such as fishing and stocking clubs, or regional councils for construction, installation, promotion, and monitoring of FAS in regional impoundments.
Environmental	• Nil.
Social	• Driving the increased flow of regional tourism, the investment in FAS has improved recreational amenity for local anglers and intra-state/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed.

Public versus Private Impacts

The investment in the FAS RD&E in the Cressbrook and Kinchant Dams is likely to produce both public and private impacts. Private impacts will be delivered through increased income for some tourism businesses in regional communities and, potentially, increased costs for some community groups for construction and installation of FAS. Public benefits are likely to be achieved through improved amenity for local anglers and angling tourists fishing regional impoundments, and through improved ecosystem health.

Distribution of Private Impacts

Private impacts will accrue initially to regional tourism businesses associated with recreational fishing (for example, bait shops, fishing gear retailers, and providers of local accommodation services) and to regional community groups and local councils. However, over the long-term benefits and costs are likely to be distributed along recreational fishing supply chains according to relevant supply and demand elasticities.

Impacts on Other Australian Industries

The FAS research investigated and evaluated FAS in freshwater impoundments for recreational fishing. It is possible that the research may have implications for other waterbody types and/or other fisheries sectors, though the details of such potential impacts was unknown.

Impacts Overseas

No direct impacts to overseas parties were identified. However, some impacts on the recreational fishing sector in other countries may occur through the sharing of scientific knowledge and international fisheries networks.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table B5. The projects included in the current analysis have contributed to National Science and Research Priority 2. The FAS RD&E investment was not likely to directly contribute to any of the four Agricultural Innovation Priorities. However, the investment may contribute indirectly to Innovation Priority 2 through any long-term improvements to impoundment ecosystem health.

Table B5: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. **Food** – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. 2. **Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. 3. **Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. 4. **Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. 5. **Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. 6. **Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. 7. **Environmental Change** – mitigating, managing or adapting to changes in the environment. 8. **Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. 1. Australia is a trusted exporter of premium food and agricultural products by 2030 2. Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 3. Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 4. Australia is a mature adopter, developer and exporter of digital agriculture by 2030 Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation and decision making around QLD's future investment are reproduced in Table B6.

The investment addressed QLD Agriculture and Food RD&E Roadmap's Strategy 3 through support for regional tourism through recreational fishing. In terms of Investment Decision Rules, the investment is likely to have real future impact through the potential of FAS to create a sustained in-flow of angler tourists to regional impoundments. Also, the investment demonstrated external commitment through the active participation and co-investment by regional community groups (local angling and stocking groups).

Table B6: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The investment in FAS RD&E has contributed to DAF Strategic Objective 2, with some contribution to Strategic Objective 5.

Case Study

The following section provides a real-world example of how the outputs of the FAS research, funded by DAF and others, have been adopted/implemented and demonstrates how recreational fishers and regional communities are benefitting from the investment.

Case Study 1: Toowoomba District Fish Stocking Association – working together to improve impoundment fisheries

Peter Taylor, President of the Toowoomba and District Fish Stocking Association (TDFSA), provided the following comments on FRDC Project 2017-019 in June 2022:

"I was heavily involved in this project from start to finish with Andrew Norris starting with the planning process which included spending many hours out on the water identifying the best position / location to install the FAS to best suit the different seasons (summer/winter) along with angler participation, both land based and boat, and types of structures."

"TDFSA members (volunteers) spent quite a few working bees to help build the FAS and TDFSA also invested in the purchase of 300 extra electro-digital tags to be used on Golden Perch as the initial project only allowed for 300 tags for Bass and we wanted Golden Perch information."

"The benefits from this project not only improved the catch rate for local anglers but will increase the number of visiting anglers (tourists) to the area which in turn will help local businesses in the region."

"Also, it was great to see three levels of government involved in the project which included Local Council/ State Government/ Federal funding."

"Overall, it has been a successful project which in turn will help other impoundments to incorporate this program and improve fisheries throughout Queensland and Nationally."

Valuation of Impacts

Impacts Valued

Two of the impacts identified in Table B3 were valued in the assessment. The two impacts were:

- Improved recreational amenity for local anglers and intra-state/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed.
- Some increased costs for community groups, such as fishing and stocking clubs, or regional councils for construction, installation, promotion, and monitoring of FAS in regional impoundments.

The two impacts were valued using a single benefit framework underpinned by the assumption that the investment in FAS in the Cressbrook and Kinchant dams has led to a net increase in the value of recreational amenity for anglers at impoundments at current and future impoundments where FAS are installed.

Valuation of Impact 1: Net increase in recreational amenity for impoundment anglers

Increased recreational amenity for regional fishers was a key impact of the investment and would contribute to the future sustainable flow of intra- and inter-state regional tourism. The valuation of increased recreational amenity of fishing typically requires the application of complex and/or resource intensive non-market valuation methods that are beyond the scope of the current analysis. However, a study by Rolfe and Prayaga (2007) estimated values for improved recreation fishing at freshwater dams in QLD. The data from this study were applied to the valuation of impacts from investment in FAS using a benefit transfer approach. Rolfe and Prayaga (2007) used both a travel cost and contingent valuation method (CVM) for three major freshwater impoundments in QLD. The CVM produced an estimated additional margin benefit of recreational angling for a 20% improvement in fishing experience at between $19.02/fisher/year and $43.03/fisher/year in 2007 dollar terms. The improvement in fishing experience was defined as a 20% improvement in catch.

Further, the estimated cost of different types of FAS were reported in the Final Report for the project. Some commercially available FAS varied in cost from $30.60 (low cost estimate for synthetic horizontal fence) to $612 (high cost estimate for reef balls), though many of the commercial FAS are not currently available in Australia (Andrew Norris, pers. comm., 2022).

Specific assumptions for the valuation of Impact 1 are described in Table B7 below.

Impacts Not Valued

Not all of the impacts identified in Table B3 could be valued within the scope of the assessment. One impact was not valued, this impact was:

- Increased future income for tourism related businesses in regional communities where FAS are constructed and installed to increase the in-flow of intra-state and inter-state regional angling tourists. Though this was considered the primary goal of the research investment and the most important impact of the FAS RD&E investment, this impact was not valued because the CBA method used for the DAF assessment considers all costs and benefits to all parties within Australia. Therefore, increased regional incomes from intra- and inter-state regional tourism represents a transfer payment. However, any future increase in regional incomes from overseas tourism attributable to the installation of FAS in QLD impoundments may be partially attributable to the project investment.

Summary of Assumptions

Table B7 describes the assumptions used in the valuation of impacts.

Table B7: Summary of Impact Valuation Assumptions

Variable	Assumption/Value	Source/Notes
Total no. of stocked impoundments in QLD	63	Based on the number of impoundments that require a Stocked Impoundment Scheme Permit in QLD Source: https://www.qld.gov.au/recreation/activities/boating-fishing/rec-fishing/dams
Total number of recreational fishers in QLD	660,000	QLD 2019/20 State-wide recreational fishing survey Source: https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-research/monitoring-reporting/statewide-recreational-fishing-surveys
Proportion of fishers undertaking fishing effort in QLD impoundments	10%	Based on an estimate that at least 6% of all fishing effort in QLD occurs in freshwater locations (Gregg, D. & Rolfe, J., 2013) and supported by data showing 37,545 permits were sold for fishing in stocked impoundments in 2019/20 (Andrew Norris, pers. comm., 2022) and that some fishers undertaking fishing as a family activity under the one permit.
Estimated mean willingness to pay for a 20% improvement in fishing experience through the installation of FAS	$43/fisher/year	Conservative estimate of $30/fisher/year based on CVM data reported in Rolfe & Prayaga (2007) and updated to 2021/22 dollar terms using the relevant Implicit Price Deflator for Gross Domestic Product (ABS, 2022). Note: valuation assumes that all fishers visiting impoundments where FAS are installed would receive some increase in amenity through the improved distribution of fish.
No. of QLD impoundments where FAS are adopted to improve the recreational fishing experience	30	Analyst assumption – assumes approximately 50% of QLD stocked impoundments adopt FAS. Based on evidence of interest in FAS reported in the FRDC Project 2017-019 Final Report and that five pilot sites have been trialled already.
Total no. of recreational fishers potentially benefiting from installation of FAS	31,429	660,000 x 10% x 30/63 Note: assumes even distribution of rec. fishers between all QLD impoundments.
Average additional cost to community groups/local councils to install FAS	$25,000 in the first year of installation	Based on the project expenditure of approximately $21,500 on purchasing FAS materials. Also, noting that, though 500 FAS were used in the Cressbrook dam project, the number of FAS needed for practical use in QLD impoundments would be lower. For example, in Kinchant dam only 194 structures were used to create 36 angling hot spots with the dam being almost twice the size of Cressbrook (Andrew Norris, pers. comm., 2022).
Ongoing average annual cost to remove and replace degraded FAS	$1,000 per year after the first year of installation	

First year of impact	2022/23	Based on successful completion of the projects in 2020/21 and allowing some time for recovery from the global COVID-19 pandemic and the continued development of policy for the use of FAS in QLD.
Year of maximum impact	2031/32 (10 years after first year of impact)	Analyst assumption – suggests estimated adoption of FAS at two to three additional impoundments each year.
Other Factors		
Attribution of benefits to the investment in the two DAF FAS RD&E projects	60%	Analyst assumption – noting that other work on FAS was undertaken internationally, that the DAF projects represent investment in only two FAS pilot studies, and that additional RD&E investment is required to both encourage adoption and to optimise the use and cost-effectiveness of FAS.
Probability of output	100%	Based on successful completion of the projects and demonstrated use of the FAS during the project.
Probability of outcome	80%	Analyst assumption – takes into account that the level of adoption assumed (25 impoundments over 10 years) is somewhat uncertain.
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect the actual benefits realised (e.g. climate change).
Counterfactual	It was assumed that, without the investment in FAS research in Cressbrook Dam and Kinchant Dam, the benefits estimated would not have occurred. This assumption was supported by the relative lack of investment in impoundment habitat enhancement RD&E and existing fisheries management practices prior to the project.	

Results

All benefit and cost cash flows were expressed in real 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022). All past and future benefit and cost cash flows were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of the investment (2020/21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Table B8 and Table B9 show the investment criteria estimated for different periods of benefits for the total investment in FAS RD&E and for the DAF investment respectively. The present value of benefits (PVB) for the DAF investment was estimated by multiplying the total PVB by the relative proportion of DAF investment in real, undiscounted dollar terms (75.5%).

Table B8: Investment Criteria for the Total Investment in FAS RD&E

Investment Criteria	**Years from last year of investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.34	1.49	2.89	4.00	4.87	5.55
Present Value of Costs ($m)	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Net Present Value ($m)	-1.85	-1.51	-0.36	1.04	2.15	3.02	3.70
Benefit-Cost Ratio	0.00	0.18	0.81	1.57	2.17	2.64	3.01
Internal Rate of Return (%)	n.s.	negative	negative	3.9	5.9	6.7	7.1
MIRR (%)	negative	negative	3.4	7.5	8.4	8.6	8.5

n.s.: no unique solution

Table B9: Investment Criteria for the DAF Only Investment in FAS RD&E

Investment Criteria	**Years from last year of investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.26	1.12	2.18	3.02	3.68	4.19
Present Value of Costs ($m)	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Net Present Value ($m)	-1.40	-1.14	-0.27	0.78	1.62	2.28	2.79
Benefit-Cost Ratio	0.00	0.18	0.80	1.56	2.16	2.63	3.00
Internal Rate of Return (%)	n.s.	negative	negative	3.8	5.8	6.6	7.0
MIRR (%)	negative	negative	3.4	7.5	8.4	8.6	8.4

n.s.: no unique solution

The annual undiscounted benefit and cost cash flows for the total project investment for the duration of the investment plus 30 years from the last year of investment are shown in Figure B1 below.

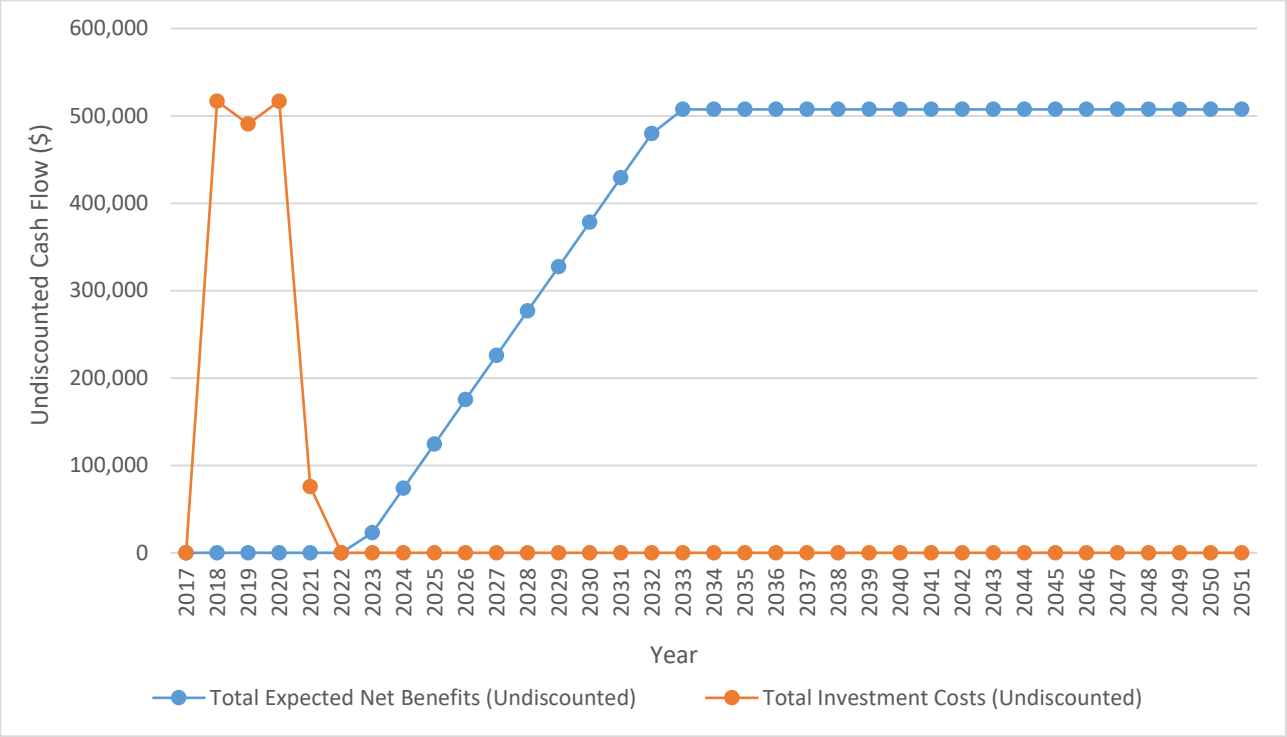

Figure B1: Annual Undiscounted Total Net Benefit and Total Investment Cost Cash Flows

Sensitivity Analyses

Sensitivity analyses were carried out on variables that were (a) considered key drivers of the investment criteria and/or (b) considered the most uncertain. The analyses were performed for the total proposed project investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

A sensitivity analysis was carried out on the discount rate. Table B10 presents the results that show a moderate sensitivity to the discount rate. This was largely because the benefit cash flows occur well into the future and were therefore subject to relatively more severe discounting.

Table B10: Sensitivity of Investment Criteria to the Discount Rate

Investment Criteria	**Discount Rate**		
	0.0%	**5.0% (Base)**	**10.0%**
Present Value of Benefits ($m)	12.16	5.55	2.94
Present Value of Costs ($m)	1.60	1.85	2.12
Net Present Value ($m)	10.56	3.70	0.82
Benefit-Cost Ratio	7.60	3.01	1.39

The assumption of the monetary value of increased recreational amenity (value of improved fishing experience) was a key driver of the investment criteria and was somewhat uncertain. A sensitivity analysis was carried out on the value of increased recreational amenity for regional anglers at impoundments where FAS are installed. The results, presented in Table B11, show a moderate to low sensitivity to the assumed value of increased amenity for recreational fisher. A break-even analysis indicated that the investment criteria remain positive (that is, a benefit cost ratio of 1 to 1 or greater) even when the value of increased amenity drops to $15.98 per fisher per year (with all other parameters at base values).

Table B11: Sensitivity of Investment Criteria to the Value of Increased Recreational Amenity for Regional Fishers

Investment Criteria	Value of Increased Recreational Amenity per Fisher per Year		
	$20.00	**$43.00 (Base)**	**$60.00**
Present Value of Benefits ($m)	2.40	5.55	7.88
Present Value of Costs ($m)	1.85	1.85	1.85
Net Present Value ($m)	0.55	3.70	6.03
Benefit-Cost Ratio	1.30	3.01	4.27

A sensitivity analysis then was conducted on the assumed number of regional impoundments adopting FAS as part of broader fisheries management strategy. Table B12 shows the sensitivity results. The investment criteria showed a moderate to low sensitivity to the total number of regional impoundments adopting FAS. A break-even analysis showed that the investment criteria remained positive when the total number of regional QLD impoundments adopting FAS declined to just 10 impoundments (all other parameters held at base values).

Table B12: Sensitivity of Investment Criteria to the Total Number of Regional QLD Impoundments Adopting FAS

Investment Criteria	Number of Regional QLD Impoundments Adopting FAS		
	15	**30 (base)**	**45**
Present Value of Benefits ($m)	2.77	5.55	8.32
Present Value of Costs ($m)	1.85	1.85	1.85
Net Present Value ($m)	0.93	3.70	6.48
Benefit-Cost Ratio	1.50	3.01	4.51

The sensitivity analyses suggest that, even when using relatively pessimistic assumptions for key variables, the investment criteria remain positive. This should give confidence to DAF, DAF RD&E funding partners, and industry stakeholders that the investment in FAS RD&E has, and will, produce positive benefits for regional fishers and regional QLD communities.

Confidence Rating and Other Findings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table B13). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table B13: Confidence in Analysis of Investment

Coverage of Benefits	Confidence in Assumptions
High	Medium

Coverage of benefits was assessed as High. Two of three impacts identified were valued in monetary terms and the impacts valued in the single benefit valuation framework included one benefit (increased recreational amenity for regional fishers) that was a key driver for the impact not able to be valued in the assessment (increased incomes for tourism businesses in regional QLD communities).

Confidence in assumptions for the impact valued was rated as Medium. Many of the assumptions used in the valuation of impacts were underpinned by scientific literature, credible data, and/or expert opinion. However, assumptions regarding the future adoption of FAS and the attribution of benefits to the project investment were uncertain.

Discussion and Conclusions

The investment in FAS RD&E through DAF projects in Cressbrook Dam and Kinchant Dam has provided evidence that FAS positively affect fish abundance and aggregation and can be used to improve the fishing opportunities and experience for anglers in regional impoundments. Construction and deployment of FAS in regional QLD impoundments was also shown to be a potentially useful tool for regional fisheries managers, in conjunction with stocking and harvest restrictions, to improve recreational fishing opportunities and the value of regional impoundment fisheries to local communities.

There has been significant interest in the implementation of FAS from anglers and stocking groups. Major waterway operators in QLD also have received multiple enquiries from stocking groups wishing to install FAS. Although no additional FAS projects have yet commenced, and policy relating to the use of FAS in QLD impoundments is still being developed, it is expected that the use of FAS in impoundment fisheries will be encouraged following the development of appropriate guidelines.

The investment in FAS RD&E has led to a number of potential positive impacts. The primary potential impact of the investment is increased future income for tourism related businesses in regional communities where FAS are constructed and installed because of a sustainable increase in the flow of intra-state and inter-state regional angling tourists. Further, though there are some additional costs incurred by stocking groups, regional councils or others installing FAS, the investment in FAS has contributed to improved recreational amenity for local anglers as well as intra-/inter-state regional angling tourists through more reliable and higher catch-rates of target fish species where FAS are installed.

The total investment in the two FAS RD&E projects was estimated at $1.85 million (present value terms) and produced total expected net benefits of approximately $5.55 million (present value terms). This gave an estimated net present value of $3.70 million, a benefit-cost ratio of 3.0 to 1, an internal rate of return of 7.1% and a MIRR of 8.5% (over 30 years, using a 5% discount rate and 5% reinvestment rate for the MIRR).

Sensitivity analyses on key variables showed that the investment criteria remained positive even when relatively pessimistic assumptions were used. This should provide confidence that the investment has produced positive benefits for regional fishers and regional QLD communities.

Overall, the assessment of DAF investment in the FAS RD&E found that the projects produced useful outputs that were well received by end-users and other stakeholders. Also, the projects have, and are likely to, deliver positive impacts for regional QLD communities, impoundment anglers, and the broader Australian community. The investment should be viewed favourably by DAF, DAF funding partners, and fishing industry stakeholders.

References

Agtrans Research. (2019). *Cross-RDC Impact Assessment 2019.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Agtrans Research; AgEconPlus; and EconSearch. (2016). *Cross-RDC Impact Assessment and Performance Reporting Update.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/impact-assessment-and-performance/

Australian Bureau of Agricultural and Resource Economics and Sciences. (2021, October 6). *Fisheries and Aquaculture Statistics 2020.* Retrieved from Australian Government - Department of Agriculture, Water and the Environment ABARES: https://www.awe.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics#download-full-report

Australian Bureau of Statistics. (2022, March 02). *Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Australian Government. (2015, May). Science and Research Priorities. *Science*. Department of Industry, Science, Energy and Resources. Retrieved from https://www.industry.gov.au/data-and-publications/science-and-research-priorities

Australian Government. (2022, January 13). *Agriculture, Forestry and Fishing: Regional Industry Data*. Retrieved from Australian Government - Labour Market Information Portal: https://lmip.gov.au/default.aspx?LMIP/GainInsights/IndustryInformation/AgricultureForestryandFishing

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved January 2022, from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Department of Agriculture, Water and the Environment. (2019, November 4). *Rural Research, Development and Extension Priorities*. Retrieved from Australian Government - Department of Agriculture, Water and the Environment: https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/priorities

Queensland Government. (2021, June 30). *Strategic Plan.* Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/abd980b2-8b50-4024-8d13-f6b36316e101/daf-strategic-plan-2019-23-refreshed-updated.pdf?ETag=cfc88f3a81d8d2db2c185a5a2321b263

Queensland Government. (2022, June 28). *Strategic Plan 2021-2025.* Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Appendix C: An Impact Assessment of Investment in Improving the Competitiveness of Australian Vegetable Exports: Augmenting Existing Export Opportunities

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Jodie Campbell, Project Principal Investigator, Supply Chain Innovation Team, Agri-Sciences Queensland, Department of Agriculture and Fisheries.

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
CA	Controlled Atmosphere
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
GDP	Gross Domestic Product
GQFE	Growing QLD's Food Exports grant program
QLD	Queensland
MAP	Modified Atmosphere Packaging
MIRR	Modified Internal Rate of Return
R&D	Research and Development
RD&E	Research, Development and Extension
TIQ	Trade and Investment QLD
UQ	University of Queensland
US	United States
VIES	AUSVEG Vegetable Industry Export Strategy 2021-2025

Executive Summary

The investment in an augmenting of existing export opportunities project has delivered data and recommendations on the sea freight export of broccoli, sweet corn and whole head iceberg lettuce to Asia, as well as sweet corn and green beans to New Zealand. Data and recommendations will inform the next phase of the industry's export development program.

Vegetable exports have largely relied on air freight to Asia and New Zealand. Developing sea freight supply chains into these markets will allow Australian growers to be more competitive. Prior to this project, there have been *ad hoc* sea fright shipments to Asia and New Zealand but the quality on arrival has been variable. In time, the knowledge garnered by this project and future research is likely to create reliable sea freight supply chains and further profitable sales opportunities for Australian vegetable growers.

The total investment in the augmenting existing export opportunities project by all contributors of $0.38 million (present value terms) has been estimated to produce total gross benefits of $1.06 million (present value terms) providing a net present value of $0.68 million, a benefit-cost ratio of 2.8 to 1 (over 30 years using a 5% discount rate), an internal rate of return of 7.3% and a modified internal rate of return of 8.0%.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 3 (Vegetable Exports). The investment included a single RD&E project funded over the period July 2020 to March 2021 title: *HF11624 improving the competitiveness of Australian vegetable exports: augmenting existing vegetable export opportunities*.

Method

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 includes both qualitative and quantitative assessment components that are in accord with the impact assessment guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

The AUSVEG Vegetable Industry Export Strategy (VIES) 2021-2025 was developed after wide consultation with the Australian vegetable industry and its stakeholders. The VIES articulates a two-pronged approach to export development: (1) Recover and sustain trade post the COVID-19 pandemic – with total exports valued at $300 million by 2023, and (2) Drive growth with total exports valued at $400 million by 2025[1]. DAF project *HF11624 improving the competitiveness of Australian vegetable exports: augmenting existing vegetable export opportunities* aligned directly with targets set in the VIES.

Recent work through the Growing QLD's Food Exports (GQFE) grant program had shown that Australia's major Asian market competitors, such as the United States (US), were predominantly delivering vegetables using cost effective sea freight. This competitor advantage, coupled with a worldwide shortage of air freight and its corresponding cost increase, highlighted the need to develop effective and efficient sea freight supply chains for Australian vegetables. To achieve effective and efficient supply chains there was a need to:

- Understand which cultivars are robust enough to endure long timeframe supply chains but still meet the product requirements of the target market.
- Understand production systems to maximise robustness and quality (pre-harvest).
- Evaluate cultivar performance throughout the supply chain through monitoring (and simulation) of varying supply chain conditions and packaging options.

To deliver the project, DAF partnered with AUSVEG and key vegetable export businesses to maximise adoption and build demonstration supply chains. DAF also partnered with Trade and Investment QLD (TIQ) to assist with market knowledge and identification of suitable in-country supply chain businesses. Key lessons and resources were then to be provided for wider industry benefit.

Three case studies were completed as part of the project:

- Case study 1: Improving performance and consistency of sea freight broccoli to Japan and Taiwan.
- Case study 2: Understanding and developing sea freight best practice for pre-packed and loose green beans and sweet corn.
- Case study 3: Identifying iceberg lettuce cultivars to maximise quality in export sea freight supply chains.

Australian vegetable exports have largely relied on air freight to Asia and New Zealand. Developing sea freight supply chains into these markets would allow Australian growers to be more competitive. Prior to this project, there had been *ad hoc* sea fright shipments to Asia and New Zealand but the quality on arrival has been variable. Some shipments arrive in sound condition, and some don't. Hence the need for research and improvement (Jodie Campbell, pers. comm., 2022).

Australia's recent performance in the export of the case study commodities is shown in the table below. Case study commodities accounted for approximately 10% of the value of Australian vegetable exports. New Zealand takes 96% of Australia's green bean exports, Singapore takes 66% of broccoli and 88% of lettuce heads. Very little sweet corn is exported by Australia.

[1] According to the Global Trade Atlas, in 2020 Australian vegetable exports totaled $263 m, in 2021 it was $251 m.

Table C1: Australian Export of Case Study Vegetables 2017-2021

Commodity	**2017**	**2018**	**2019**	**2020**	**2021**	**AVG**
Green bean (t)	1,594	1,639	1,741	1,633	1,415	1,604
Green bean ($m)	6.9	6.9	7.3	8.7	6.6	7.3
Broccoli (t)	5010	5,861	6,633	5,169	3,619	5,258
Broccoli ($m)	15.3	16.0	19.5	19.7	15.3	17.2
Sweet corn (t)	0	0	0	0	0	0
Sweet corn ($m)	0	0	0	0	0	0
Lettuce - head (t)	194	432	565	427	381	400
Lettuce - head ($m)	1.3	1.7	1.8	1.3	1.2	1.5

Source: Australian Horticulture Statistics Handbook – various years

Project Details

Summary

Project Code: HF11624

Title: *Improving competitiveness of Australian vegetable exports: augmenting existing vegetable export opportunities*

Research Organisation: DAF, Agri-Sciences

Principal Investigator: Jodie Campbell, Principal Horticulturalist (Supply Chains)

Period of Funding: July 2020 to March 2021

Objectives

The project aimed to demonstrate a range of collaborative activities that would assist in building the export capability and competitiveness of the Australian vegetable industry through:

- Understanding the competitive environment in target markets and windows of supply opportunity, product requirements, and supply chain conditions.
- Analysing existing and new supply chains to recommend improvements and efficiencies.
- Conducting simulation experiments to enrich monitoring data and decision aid tool development.
- Facilitating improved knowledge and decision-making along the supply chain by participation in supply chain analysis and making recommendations for future development of information resources and decision aid tools.

Logical Framework

Table C2 describes the investment in Project HF11624 in a logical framework and includes a summary of project activities, outputs, actual and expected outputs, and potential impacts associated with the outcomes.

Table C2: Logical Framework for Project HF11624

Activities	• Information exchange meetings were convened for three sets of case study collaborators. • Target market segments and supply chains were identified for each case study commodity using AUSVEG/commercial collaborators, TIQ, and researcher knowledge. The product specifications then were summarised for each segment and suitable cultivars were identified. • A monitoring protocol for each sea freight supply chain was developed and implemented. Each supply chain was mapped and relevant data on production history was obtained (e.g., fertiliser, sprays, temperature, rainfall) for shipped consignments. Monitoring procedures, checklists and guidelines were implemented to assess the cold chain and handling practices and build communication between study collaborators. The cold chain data and analysis of handling practices were assessed and interpreted, and reports provided on each shipment including recommendations for improvement. • A range of simulation sea freight trials were conducted to supplement the sea freight monitoring exercise. The project team worked with AUSVEG/collaborating growers to identify market opportunities. Product samples were obtained and information on their production history gathered.

	• Harvest and pack samples were held under standard commercial conditions. Held samples were tested under simulated sea freight conditions. Simulated sea freight and shelf-life conditions for five temperature and duration combinations were assessed. Sample quality was assessed at removal, then held product at temperatures approximating those found in the importing country retail. Residual shelf-life also was measured. • Recommendations were developed for the future development of decision aid tools and information resources.

Outputs	• *Improving sea freight broccoli to Japan and Taiwan:* Broccoli sea freighted to Asia sometimes has inconsistent quality. The project showed that this can be because shipping container temperatures vary above and below the set point. This can cause the ice that is packed around the broccoli to melt and refreeze resulting in chilling or freezing injury. Key learnings included:
	  • Optimal shelf-life was achieved by combining top ice with Modified Atmosphere Packaging (MAP).
	  • The next best options were the traditional top icing treatment or the MAP liners (no ice) alone.
	  • The ideal shipping temperature was close to zero degrees.
	  • Increasing temperatures to 4^{o}C reduced self-life by up to 7 days, particularly for longer storage.
	• *Developing sea freight best practice for sweet corn and green beans:* Fresh sweet corn is a relatively new product to Japanese consumers who prefer green, fully husked cobs or semi-husked pre-pack cobettes. Sea freight to Japan was simulated for both loose fully husked corn in perforated liners and semi-husked pre-pack cobettes at 1^{o}C (optimum temperature) for 15 days with and without Controlled Atmosphere (CA – 3% O_2, 15% CO^2). With short shipping times to the relatively small New Zealand market of around 6 days, there was an opportunity to send product more frequently, without Controlled Atmosphere, and as a mixed shipment. The study examined the possibility of shipping sweet corn and green beans together despite their different optimum storage temperatures. Key learnings were:
	  • Shipping sweet corn under a CA model doubled shelf-life on arrival in market to between 7 and 10 days.
	  • Working with cultivars that were previously identified as offering improved shelf-life, the study found that sweet corn and green beans could be shipped at 5^{o}C to provide a shelf-life of 10 days for both products.
	• *Identifying iceberg lettuce cultivars with export potential:* Iceberg lettuce has become an increasingly popular product in the Japanese food service sector. The project identified that a new series of cultivars with the Knox^{TM} delayed browning trait, developed by Rijk Zwaan, displayed improved quality after simulated sea freight over current commercial standards.
	• *Overarching lessons:* The development of sea freight supply chains that deliver consistent and predictable quality vegetables to export markets should consider:
	  • Selection of cultivars with characteristics that meet consumer expectations and with sufficient robustness to handle sea freight conditions.

	• Evaluate MAP and CA treatments to further extend storage life and reduce risks associated with sea freight. • Examine time/temperature impacts on quality/shelf-life of specific vegetables to provide exporters with knowledge and confidence in sea freight. • The project generated grower focussed datasets to be used in future research, and cultivar selection for export. • Research reports and communication materials (fact sheets, monitoring reports) were generated and these included recommendations for future export development activities. • Articles were prepared for Vegetables Australia magazine and the vegetable industry's communications program. • Case study pilots were completed to inform the next phase of the industry's export development program. • Grower learnings and data were incorporated into the Vegetable Strategic Investment Plan (SIP 2022-2026). • Case studies were featured at Hort Connections 2021.
Actual and Expected Outcomes	• Progress toward successful sea freight of Australian vegetables to export markets in Asia (e.g., Japan, Taiwan, Singapore) and New Zealand. • Initial success expected with relevant cultivars of broccoli, green beans, sweet corn, and iceberg lettuce. • Knowledge generated may, in the longer term, also be relevant to other export markets (e.g. Middle East) and crops (e.g. cauliflower).
Potential Impacts	• A contribution to additional profitable sales for vegetable growers (broccoli, green beans, sweet corn, iceberg lettuce, etc.) in Asia and New Zealand in the future. • Increased researcher capacity in analysis of sea freight supply chains. • Increased grower capacity in supplying vegetables through sea freight systems. • Increased income in regional Australia associated with a more profitable and sustainable vegetable industry.

Source: DAF project documentation and consultation with project personnel.

Nominal Investment

Table C3 shows the total annual investment made in *HF11624 Improving the competitiveness of Australian vegetable exports, augmenting existing export opportunities* by DAF, University of Queensland (UQ), and commercial businesses. Total includes cash and in-kind contributions.

Table C3: Total Investment in HF11624
(nominal dollar terms)

Year ended 30 June	DAF ($)	UQ ($)	Commercial Businesses ($)	Total ($)
2021	235,000	26,000	60,000	321,000
Totals	**235,000**	**26,000**	**60,000**	**321,000**

Source: Project agreement and variations

Management and Administration Costs

For the DAF investment, the management and administration costs for the project were assumed to already be built into the nominal dollar amounts appearing in Table C3. The salary multiplier that had been used by DAF was a 2.85 multiplier for salaries contributed by DAF (Wayne Hall, pers. comm., 2017).

For the other investment, it was assumed that the investment costs reported included any management and administration costs. Therefore, a management cost multiplier of 1.0 was applied to all the other financial contributions shown in Table C3.

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2022).

Impacts

Table C4 provides a summary of the principal types of potential impacts from investment in Project *HF11624 Improving the competitiveness of Australian vegetable exports, augmenting existing export opportunities*. Impacts have been taken from Table C2 and categorised using a triple bottom line framework into economic, environmental and social impact types.

Table C4: Principal Potential Impact Types from Investment in HF11624 Improving the Competitiveness of Australian Vegetable Exports, Augmenting Existing Export Opportunities

Economic	• A contribution to additional profitable sales for vegetable growers (broccoli, green beans, sweet corn, iceberg lettuce, etc.) in Asia and New Zealand in the future.
Environmental	• Nil.
Social	• Increased researcher capacity in analysis of sea freight supply chains. • Increased grower capacity in supplying vegetables through sea freight systems. • Increased income in regional Australia associated with a more profitable and sustainable vegetable industry.

Public versus Private Impacts

The project will generate mostly private impacts. The principal private impact is a contribution to future additional profitable vegetable sales in export markets. A second private impact is increased vegetable grower capacity in supplying vegetables through sea freight systems. Public impacts include social benefits associated with enhanced researcher capacity and spill-over income and employment benefits in regional communities.

Distribution of Private Impacts

The potential private impacts from this project will be shared along the sea freight vegetable export supply chain with growers, packers, export marketers, importers, overseas retailers, and consumers all realising some of the potential impacts. The share of benefits retained by each link in the supply chain will depend on ruling short- and long-term supply and demand elasticities.

Impacts on Other Australian Industries

It is likely that findings from this research project will be confined to the vegetable industry. Project outputs were focussed on specific vegetable types and cultivars delivered using simulated sea freight conditions and supply chain monitoring to particular overseas markets. However, it is noted that researcher capacity developed as part of the project may have relevance to other fresh commodity exports, e.g. fruit or fresh chilled red meat.

Impacts Overseas

Learnings in relation to maximising the quality and shelf-life of sea freighted Australian vegetables will be equally as applicable to other exporters of green beans, broccoli, sweet corn, and iceberg lettuce, e.g. South Africa, Chile, Peru and Argentina. It was noted that technical detail generated by this project remains commercial-in-confidence and has not been published.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table C5. The DAF vegetable sea freight project has contributed to National Science and Research Priority 1 and potentially 3. Further, the RD&E investment is likely to contribute to Agricultural Innovation Priority 1.

Table C5: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030 **2.** Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 **4.** Australia is a mature adopter, developer and exporter of digital agriculture by 2030 Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation and decision-making around QLD's future investment are reproduced in Table C6.

The investment addressed QLD Agriculture and Food RD&E Roadmap's Strategy 1 (increase innovation and commercialisation) and 3 (support existing sector to grow and develop new business). In terms of Investment Decision Rules, the investment is likely to have a real future impact i.e., increased vegetable exports. The investment also secured external commitment through UQ and relevant commercial businesses.

Table C6: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The investment in Project HF11624 has contributed to DAF Strategic Objective 1, with some contribution to Strategic Objective 3.

Case Study

The following section provides real world feedback on how the outputs of Project *HF11624, Improving the competitiveness of Australian vegetable exports: augmenting existing vegetable export opportunities* will impact the Australian vegetable industry.

Case Study 1: Full steam ahead for iceberg lettuce and other export vegetables research

AUSVEG National Manager – Export Development Michael Coote explained in a press release (Friday, 12 March 2021) that the value of national fresh vegetable exports dipped as a result of disruptions caused by COVID-19.

"The pandemic has disrupted both sea and air freight over the past 12 months. Adding to the challenges that exporters have faced trying to continue servicing their customers in international markets".

"Capacity in the air freight network may take a number of years to return to pre-COVID levels, and it is anticipated that air freight prices won't return to pre-pandemic rates in the foreseeable future".

Mr Coote said investigating opportunities to move product from air freight to sea freight to service a wider range of international markets may prove critical if the air freight network does not recover in the future".

"This research project (HF11624) is important to provide vegetable exporters with additional insights into which export markets are technically viable by sea freight and will help underpin short and longer-term export growth for the industry".

Valuation of Impacts

Impacts Valued

Valuation of Impact 1: Additional profitable sales for vegetable growers

The project delivered data and a series of recommendations on the sea freight export of broccoli to Asia, sweet corn to Asia, sweet corn and green beans to New Zealand, and the export of whole head iceberg lettuce to Asia. Data and recommendations will inform the next phase of the industry's export development program. In time, the knowledge garnered by this project (HF11624) and future research is likely to create reliable sea freight supply chains and further profitable sales opportunities for Australian vegetable growers.

Attribution of Impacts to the Project

The project supported only pilot case studies and further research and commercial trials will be required before 'proof of concept' in a simulated trial and sea freight monitoring becomes a commercial proposition and vegetables are shipped using HF11624 recommendations. Consequently, a 40% attribution factor has been assumed for the attribution of benefits to the specific investment in HF12624.

In 2022, DAF are working on a further trial shipment of iceberg lettuce to Japan, kaboacha squash to Japan, and improvements in carrot sea freight to the Middle East (Jodie Campbell, pers. Comm., 2022).

Counterfactual

In the absence of this project, with expertise and funding provided by DAF, it was assumed that there was a 50% likelihood that project benefits would have been generated through an alternative source e.g., a Hort Innovation RD&E project, or research completed by large grower/exporters.

Impacts Not Valued

Three potential project impacts identified in Table C4 were not valued – increased researcher capacity, increased grower capacity, and increased income in regional Australia. These potential impacts were not valued as they were deemed to be of low relative significance when compared to the potential impact that was valued (i.e. additional profitable sales for vegetable growers).

Summary of Assumptions

A summary of assumptions and data sources is provided in Table C7 (below).

Table C7: Summary of Assumptions

Variable	Assumption	Source
Additional profitable sales for vegetable growers		
Average value of Australian vegetable exports targeted in this project (i.e. green bean, broccoli, sweet corn, and head lettuce)	$26 million	See Table C1 above, compiled using the Australian Horticulture Statistics Handbook (various editions) and spanning the 5 years 2017 to 2021
Increase in the value of vegetable exports targeted in this project when effective sea freight is in place	5%	Analyst assumption after consideration of project documentation
Year of first benefit	2024/25	Further investment and lapsed time are required to turn pilot case studies (this project) into a commercial proposition
Year of maximum benefit	2032/33	Analyst assumption that it takes eight years of successful sea freight to reach maximum assumed increase in sales
Probability of output	100%	Valuable outputs have been delivered
Probability of outcome	65%	While further research is planned, it is not certain that a technically viable sea freight proposition will be developed
Probability of impact	60%	Even if a technically viable sea freight proposition is developed, supply to targeted markets may not be profitable (e.g. US competitors may innovate and lower their supply cost)
Attribution of impact to the project.	40%	See above text
Counterfactual	50%	See above text

Results

All past costs were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP (ABS, 2022). All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Table C8 and C9 show the investment criteria estimated for different periods of benefits for the total investment and the DAF investment, respectively. The present value of benefits (PVB) attributable to DAF investment only, shown in Table C9, was estimated by multiplying the total PVB by the DAF proportion of real investment (75.0%).

Table C8: Investment Criteria for Total RD&E Investment in the Sea Freight Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.04	0.26	0.53	0.75	0.93	1.06
Present value of costs ($m)	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Net present value ($m)	-0.38	-0.34	-0.12	0.15	0.37	0.55	0.68
Benefit-cost ratio (BCR)	0.00	0.11	0.67	1.40	1.98	2.44	2.80
Internal rate of return (IRR) (%)	Negative	Negative	Negative	3.3	5.8	6.8	7.3
Modified IRR (%)	Negative	Negative	2.4	6.7	7.8	8.1	8.0

Table C9: Investment Criteria for DAF RD&E Investment in the Sea Freight Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.03	0.19	0.40	0.57	0.70	0.80
Present value of costs ($m)	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Net present value ($m)	-0.29	-0.25	-0.09	0.11	0.28	0.41	0.51
Benefit-cost ratio	0.00	0.11	0.67	1.40	1.98	2.44	2.80
Internal rate of return (IRR) (%)	Negative	Negative	Negative	3.3	5.8	6.8	7.3
Modified IRR (%)	Negative	Negative	2.4	6.7	7.8	8.1	8.0

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of investment are shown in Figure C1.

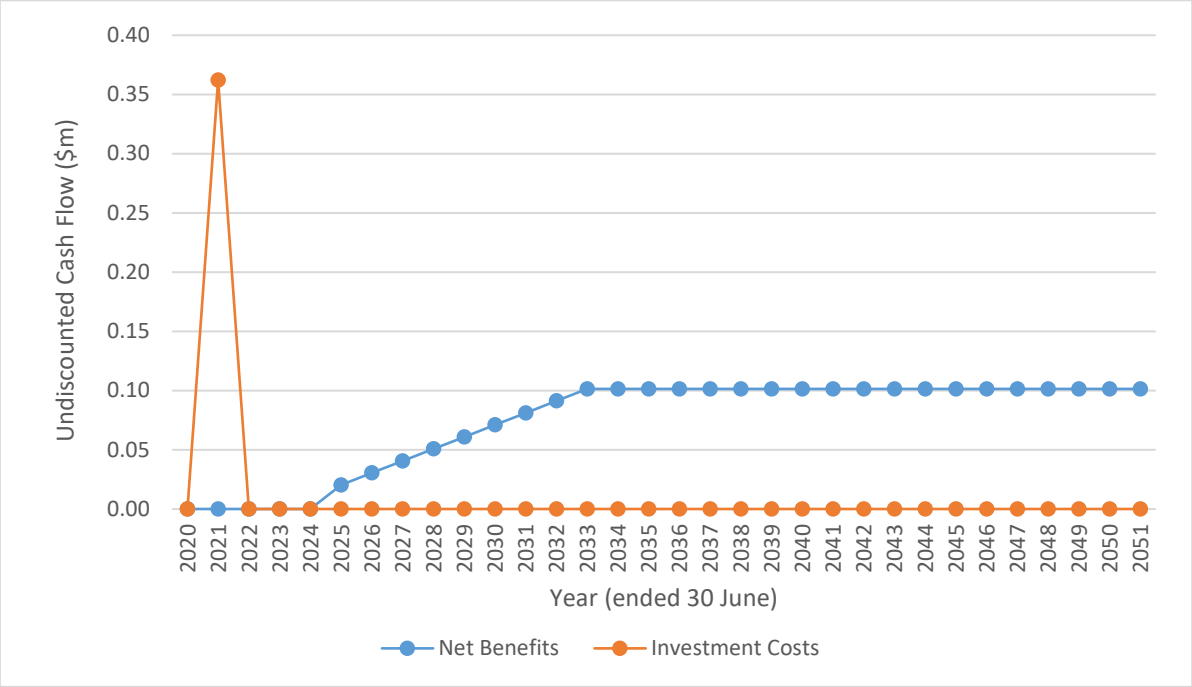

Figure C1: Annual Cash Flow of Undiscounted Total Net Benefits and Total Investment Costs

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Results are reported in Table C10. The results show that the investment criteria are only moderately sensitive to the discount rate.

Table C10: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	2.37	1.06	0.55
Present value of costs ($m)	0.36	0.38	0.40
Net present value ($m)	2.01	0.68	0.15
Benefit-cost ratio	6.55	2.80	1.38

A sensitivity analysis was then completed on the assumed increase in value of targeted vegetable exports with effective sea freight in place (Table C11). Results show that if the increase in value was only 1.5% then the project would fail to break-even i.e., project costs exceed project benefits.

Table C11: Sensitivity to Increase in Value of Targeted Vegetable Exports with Effective Sea Freight
(Total investment, 30 years)

Investment Criteria	**Increase in Value of Targeted Exports (%)**		
	1.5%	**2.5%**	**5% (base)**
Present value of benefits ($m)	0.32	0.53	1.06
Present value of costs ($m)	0.38	0.38	0.38
Net present value ($m)	-0.06	0.15	0.68
Benefit-cost ratio	0.84	1.40	2.80

Confidence Ratings and other Findings

The investment analysis results are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table C12). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table C12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
High	Medium-Low

Coverage of benefits was assessed as High. The principal benefit, additional profitable sales for vegetable growers was quantified.

Confidence in assumptions was rated as Medium-Low. Though key data and assumptions were drawn from credible sources (e.g., Australian Horticulture Statistics Handbook), there were a number of potential drivers of the impacts where values were estimated by the analyst.

Discussion and Conclusions

The augmenting of existing export opportunities project (HF11624) has delivered data and recommendations on the sea freight export of broccoli, sweet corn and whole head iceberg lettuce to Asia, as well as sweet corn and green beans to New Zealand. Data and recommendations will inform the next phase of the industry's export development program. In time, the knowledge garnered by this project and future research is likely to create reliable sea freight supply chains and further profitable sales opportunities for Australian vegetable growers.

The total investment in the augmenting existing export opportunities project by all contributors of $0.38 million (present value terms) has been estimated to produce total gross benefits of $1.06 million (present value terms) providing a net present value of $0.68 million, a benefit-cost ratio of 2.8 to 1 (over 30 years using a 5% discount rate), an internal rate of return of 7.3% and a modified internal rate of return of 8.0%.

References

Australian Bureau of Statistics. (2022, March 02). *Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving*. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Commonwealth of Australia. (2015). *Agricultural Competitiveness White Paper.* Canberra: Commonwealth of Australia. Retrieved from http://agwhitepaper.agriculture.gov.au/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf

CRRDC (2018) Council of Rural Research and Development Corporations. Cross-RDC Impact Assessment Program: Guidelines. Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Office of the Chief Scientist. (2015). *Strategic Science and Research Priorities.* Canberra: Commonwealth of Australia. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/STRATEGIC-SCIENCE-AND-RESEARCH-PRIORITIES_181214web.pdf

Office of the Chief Scientist, Queensland Government (2015) Revised Queensland Science and Research Priorities, accessed 17 February 2019 at: https://www.chiefscientist.qld.gov.au/documents/strategy-priorities/qld-science-n-research-priorities-2015-2016.pdf

Queensland Government. (2022, June 28). Strategic Plan 2021-2025. Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Appendix D: An Impact Assessment of Investment in Grain Storage: Research, development and extension to support on-farm storage of grains and pulses

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Greg Daglish, Principal Research Scientist, Department of Agriculture and Fisheries

Manoj Nayak, Principal Research Scientist, Team Leader, Postharvest Grain Protection, Department of Agriculture and Fisheries

Abbreviations and Acronyms

BMP	Best Management Practice
CBA	Cost Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Queensland Department of Agriculture and Fisheries
GDP	Gross Domestic Product
ha	Hectare
QLD	Queensland
NSW	New South Wales
R&D	Research and Development
RD&E	Research, Development and Extension

Executive Summary

This report presents the results of an impact assessment of a Queensland Department of Agriculture and Fisheries (DAF) investment in a project associated with grain storage. The project was funded by DAF over the years ending June 2020 to June 2022.

The project is first described qualitatively using a logical framework that includes project objectives, activities and outputs, outcomes and impacts. Impacts were then categorised into a triple bottom line framework. Principal impacts were then valued.

The cost-benefit analysis was conducted according to the current Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018). Benefits were estimated for a range of time frames up to 30 years from the last year of investment (2021/22). Past and future cash flows in 2021/22 dollars were discounted to the year 2021/22 using a discount rate of 5% to estimate the investment criteria.

The large investment in this project and its associated outcomes to date, have been important in driving increased profitability of the Queensland and New South Wales pulse industries. The pathway to these impacts has been through an increase in quality for some growers, as well as a reduction in costs along the value chain to market.

Total funding from all sources over the project duration was approximately $1 million in nominal terms ($1.24 million in present value terms). The value of total potential benefits due to the project are estimated at $15.22 million (present value terms). This result represented an estimated net present value of $13.98 million, a benefit-cost ratio of 12.3 to 1, an internal rate of return of 31.3% and a modified internal rate of return of 13.6%.

As there were several potential impacts identified that were not valued in monetary terms, it is most likely that the investment criteria reported may have undervalued the full value of benefits delivered by the investment.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 4 (Grains Storage Best Management Practice). The investment was funded over the period July 2019 to June 2022 and was titled: *Research, development and extension to support on-farm storage of grains and pulses.*

Method

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

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions.
- The complexity of the relevant valuation methods applicable given project resources.
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified.
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

After Canada, Australia is the second largest exporter of pulses in the world (Australian Grain Yearbook, 2022). The Queensland (QLD) pulse industry is made up largely by chickpea and mungbean; the majority of these two pulses are exported from Australia, mostly to the Indian sub-continent and the Middle East.

Chickpea (*Cicer arietinum*) is an annual legume of the family Fabaceae; it is a winter growing legume crop. At the time of initial project funding (1999/2000) the area of chickpea in QLD was estimated as 200,000 ha with a yield of 0.95 tonnes/ha (Australian Crop Report, 2019). Annual production was estimated at 190,000 tonnes.

Mungbean (*Vigna radiata*) is a summer legume crop grown largely in QLD and northern New South Wales (NSW). The grain is not only valuable as an export crop (90% exported), but, as a legume like chickpea, it has the ability to fix nitrogen and improve soil productivity. In 1999/2000, the average production over the past five years had been 90,000 tonnes per year valued at $118 million annually (Australian Mungbean Association, 2022). The QLD chickpea and mungbean combined production was valued at about $264 million in 2020/2021 (Queensland Government, 2022).

Growers of chickpea and mungbean store their product on farm for different periods in order to maximise the price received; also, storage is undertaken by some large to medium-sized companies (e.g. PBAgriFoods, OLAM, Woods Grains, AgriFoods Aust, Deacon Seeds, Bean Growers Aust). There were important knowledge gaps in the storage of pulses as most of the earlier research and development pertaining to storage had been targeted on the cereal grain industries.

The Ecosciences Precinct in Dutton Park in Brisbane opened in late 2010 and has provided a facility for researchers such as the Post-Harvest Grain Protection team from DAF. The team responded to a one million dollar Queensland Government election commitment to address knowledge gaps associated with the storage of pulses in Queensland (Queensland Government, 2018). Issues to be addressed included fumigation strategies, including the use of phosphine to manage pests during pulse storage, aeration cooling protocols to manage pulse pests on farm, and delivering an overall best management practice document for the management of pulse pests in QLD and NSW. Of particular note was that the bruchid insect that was causing the most damage in stored pulses originally had been confined to the central QLD pulse growing areas but was more recently moving south and damaging a larger area of stored pulses.

Project Details

Summary

Project Code: Not applicable

Title: *Research, development and extension to support on-farm storage of grains and pulses*

Research Organisation: Department of Agriculture and Fisheries, Queensland

Principal Investigators and Co-Project Leaders: Dr Manoj Nayak, Principal Research Scientist, Team Leader, Postharvest Grain Protection, Queensland Department of Agriculture and Fisheries; Dr Greg Dalglish, Principal Research Scientist, Queensland Department of Agriculture and Fisheries

Period of Funding: July 2019 to June 2022

Objectives

The key objective of the project was to address key gaps in knowledge to ensure the development of best management practice for stored pulses that could, in turn, deliver high quality pulses to market.

Logical Framework

Table D1: Logical Framework for Research, Development and Extension to Support On-farm Storage of Grains and Pulses

Activities	<u>Development of fumigation strategies to manage pulse pests, including the bruchids, specifically the Cowpea bruchid (*Callosobruchus maculatus* F), using the fumigant phosphine</u> • Both a laboratory strain from a field storage site at Kingaroy and field strains of insects from multiple farm samples were used in the study; the strains were inbred and regularly cultured in organic mungbean in the laboratory. • Fumigations were conducted on mungbean (variety Jade) and two types of chickpea (Desi and Kabuli). • As the adult beetles of *C. maculatus* are only short-lived, it was necessary to ensure that the insect populations assessed contained all the life stages before fumigation assays were conducted. <u>Phosphine fumigation</u> • Phosphine gas was generated from aluminium phosphide tablets. • Two phosphine gas concentrations were used in the study and each was evaluated over two or more exposure periods of up to 7 days; the objective was to assess the mortality of adult *C. maculatus* for each of mungbean and chickpea. • Each experiment was replicated twice. • Experiments with normal atmosphere air were undertaken as a control. • After the completion of fumigation, the containers with both treated and untreated insects were maintained under a controlled environment for further observation. • Screening of containers was undertaken for *C. maculatus* 7 days and 6 weeks after the fumigation end date. • The mortalities of parental adults and their progeny were estimated for each treatment and compared with the respective untreated control, in order to identify the most effective phosphine dose regime.

	<u>A silo-scale trial under field conditions</u> • A silo-scale trial was initiated at the Hermitage Research Facility in 2019 to assess phosphine efficacy against *C. maculatus* in mungbean under field conditions. • Bruchid pest populations were placed in insect cages inserted into the mungbean bulk, each at various levels, and phosphine tablets applied; one silo was not fumigated with phosphine and acted as a control. <u>Aeration protocols</u> • A laboratory investigation was undertaken of the impact of temperature on survival and reproduction of *C. maculatus* in stored mungbean. • The investigation was conducted at 15, 20, 25, and 30 degrees Celsius. • Adult survival was estimated for each temperature. <u>Industry interaction</u> • Members of the research team attended workshops throughout the project to gain additional knowledge of ongoing pulse infestation issues from growers and to communicate preliminary research findings from the project. <u>Preparation of a Best Management Practice (BMP) document</u> • A Best Management Practice (BMP) document was prepared for the grower management of pulse pests in QLD and NSW.
Outputs	• Identification of improved strategies for the use of phosphine fumigant to manage pests of pulses stored on farm. • Identification of aeration cooling strategies to slow the population growth of *C. maculatus*. • Additional industry information assembled by the research personnel regarding ongoing pulse infestation issues. • Ongoing communication to industry of findings of the project. • A draft BMP document was prepared, finalised and made available to the QLD and NSW pulse industries in early calendar 2022.
Actual and Expected Outcomes	• Application of improved strategies by some QLD and NSW pulse growers, aggregators and exporters for the management of pests for stored mungbean and chickpea. • Contribution to the potential for some growers to increase the area of pulses grown in QLD, and potentially, in NSW. • Without the additional information on pulse storage (e.g. fumigation, aeration, bruchid biology, hygiene etc.) there would have been no way of providing answers to both Australian growers and Australian commercial export businesses on how to control pests in storage and maintain the quality of pulse exports (Manoj Nayak, pers. comm., 2022).
Potential Impacts	• Increased price for some QLD and NSW pulse growers, pulse aggregators and exporters due to application of new management strategies for reducing pest damage to stored mungbean and chickpea. • Potential for increased area of Australian pulses due to greater confidence in pulse storage management strategies. • Potential for higher quality of pulses produced in QLD and NSW resulting in an increased demand from export markets.

	• The aeration-cooling protocols developed to manage pests is a non-chemical strategy that has significant environmental impact in terms of reduction in chemical use (Manoj Nayak, pers. comm., 2022). • Fumigation protocols developed to manage pests using phosphine is another way to provide safe-food to consumers, as this fumigant is globally accepted as a residue-free treatment. In addition, phosphine, when used in storages, has no green-house or other adverse impact on the environment and non-target organisms (Manoj, Nayak, pers. comm., 2022). • Research conducted on storage of pulses can have overlapping research knowledge benefits for other stored grains. Storage pest such as lesser grain borers and rust-red flour beetles will infest both pulses and cereal grains. Moreover, pest management aspects including aeration-cooling, hygiene etc. that are developed against pulse pests are applicable on pests of cereals (Manoj Nayak, pers. comm., 2022).

Source: DAF project documentation and consultation with project personnel.

Nominal Investment

Table D2 shows the total annual investment made in the project entitled Research, Development and Extension to support the Project entitled "On-Farm Storage of Grains and Pulses by DAF and other contributors".

Table D2: Total Investment in Research, Development and Extension to Support On-Farm Storage of Grains and Pulses (nominal dollar terms)

Year ended 30 June	DAF ($)	Others[(a)] ($)	Total ($)
2020	335,735	0	335,735
2021	491,642	0	491,642
2022	210,988	0	210,988
Totals	**1,038,365**	**0**	**1,038,365**

Source: Lynda Bull (DAF), pers. comm., 2022

(a) No estimates of the values of cash or in-kind contributions by others were available in project documentation. As contributions in time were made to the project by a range of industry personnel, such contributions have been indirectly recognised by using conservative assumptions regarding industry benefits

Management and Administration Costs

For the DAF investment the management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table D2. The salary multiplier that is used by DAF was a 2.85 multiplier for salaries contributed by DAF (Wayne Hall, pers. comm., 2017).

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (Australian Bureau of Statistics, 2022).

Impacts

Table D3 provides a summary of the principal types of potential impacts from the project titled "On-Farm Storage of Grains and Pulses by DAF and other contributors". Impacts have been taken and potentially expanded from those listed in Table D1 and categorised using a triple bottom line framework into economic, environmental and social impact types.

Table D3: Principal Potential Impact Types from Investment in Project Titled Research, Development and Extension to Support On-Farm Storage of Grains and Pulses

Economic	• Increased price for some QLD and NSW pulse growers that store pulses before sale, due to application of new management strategies for reducing pest damage to stored mungbean and chickpea. • Increased use of storage for some QLD and NSW pulse growers who had not stored pulses previously, resulting in higher net returns. • Increased area of QLD and NSW pulses due to greater grower confidence in pulse storage management strategies. • A reduction in losses of value by pulse aggregators and exporters due to application of new management strategies for reducing pest damage to stored mungbean and chickpea. • Higher quality of pulses produced in Queensland resulting in an increased demand and price from export markets.
Environmental	• Aeration-cooling protocols developed to manage pests is a non-chemical strategy that has significant environmental impact in terms of reduction in chemical use (Manoj Nayak, pers. comm., 2022). • Fumigation protocols developed to manage pests using phosphine is another way to provide safe-food to consumers, as this fumigant is globally accepted as a residue-free treatment. In addition, phosphine, when used in storages, has no green-house or other adverse impact on the environment and non-target organisms. It is noted that fumigant Methyl Bromide is banned for its use globally (with only limited use in shipping containers) due to its ozone-depleting nature. Another fumigant Sulfuryl fluoride that is used as a postharvest commodity disinfestant, has also been considered as a green-house gas (Manoj Nayak, pers. comm., 2022).
Social	• Increased capacity and capability of Queensland researchers regarding grain storage strategies. • A potential increase in positive regional spillover impacts from future gains in productivity by some pulse growers and their supply chains in Queensland.

Public versus Private Impacts

The principal private impact identified in this evaluation is directly related to gains to the Queensland pulse industry. The public impacts include a potential increase in the capacity and capability of Australian post-harvest researchers and some regional communities servicing the Queensland pulse industry and their supply chains.

Distribution of Private Impacts

The benefits from reduced storage losses and any additional costs will directly accrue to Queensland pulse growers in the first instance. Such private benefits will be shared by members of the various pulse supply chains according to associated supply and demand elasticities.

Impacts on Other Australian Industries

There may be some spillover impacts for the mungbean growers in northern NSW, although the project specifically targeted Queensland industry, particularly with respect to the industry involvement and extension activities. Likewise, there may be some spillover impacts captured by chickpea producers in other states of Australia.

Impacts Overseas

The major impact overseas will be an enhanced image of mungbean and chickpea exports from Queensland.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table D4. The projects included in the current analysis have contributed to National Science and Research Priority 1 (agricultural productivity). Further, the investment is likely to contribute to National Agricultural Innovation Priority 1 (Australia is a trusted exporter of premium food and agricultural products by 2030).

Table D4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030 **2.** Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 **4.** Australia is a mature adopter, developer and exporter of digital agriculture by 2030 Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation and decision making around QLD's future investment are reproduced in Table D5.

The investment addressed QLD Agriculture and Food RD&E Roadmap's Strategy 1 (Increase innovation and commercialisation) The investment also addressed Strategy 2 (Identification and promotion of agriculture and food RD&E opportunities). After the publication of pulse BMP, DAF was approached by the oilseed industry (canola, sunflower etc.) to develop similar strategies for their postharvest commodities. DAF has also been approached with similar requests from GRDC. It is noted that, historically, the postharvest commodity protection RD&E in Australia/QLD has heavily been focused on cereals. Currently, there is no best management practices for postharvest protection of oilseeds. DAF is in a good position to extend its expertise to address the RD&E gaps in this space (Manoj Nayak, pers. comm.,2022). The investment addressed also RD&E Strategy 3 (Support existing sector to grow and develop new business). In terms of Investment Decision Rule Guides, the project addressed a real future impact.

Table D5: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The investment in on-farm grain storage of grains and pulses has contributed to DAF Strategic Objective 1, with some contribution to Strategic Objective 4.

Valuation of Impacts

Impact Valued

The impact valued was an increase in the value of mungbean and chickpea sold by some of the 60% of Queensland producers that stored pulses on farm before sale.

Impacts Not Valued

The six other potential economic impacts identified in Table D3 that were not valued included the following:

- Potential losses averted by NSW growers.
- A potential reduction in losses of value by pulse aggregators and exporters due to application of new management strategies for reducing pest damage to stored mungbean and chickpea.
- Increased use of storage for some QLD and NSW pulse growers who had not stored pulses previously resulting in higher net returns.
- Increased use of storage of pulses providing higher returns for growers who had previously avoided storing pulses.
- A potential increased area of Queensland pulses due to increased grower confidence in pulse storage management strategies.
- Higher quality of pulses produced in Queensland resulting in an increased demand and price from export markets.

These potential impacts were not valued due to a lack of available supporting information, as well as the limited time and resources available.

The two social impacts identified in Table D3 that were not valued are listed below, together with the associated reasons for non-valuation:

- Increased capacity and capability of Queensland researchers regarding grain storage strategies; this impact was not valued due to insufficient resources/time and the difficulty in assembling appropriate data. Moreover, this impact was already valued in part via its contribution to the impact that was valued.
- A potential increase in positive regional spillover impacts from future gains in productivity by some pulse growers and their supply chains in Queensland. This impact was not valued as any increased economic activity and employment along the product supply chain would be difficult to value, given the number and geographic spread of pulse production across the various growing regions.

Summary of Assumptions

Specific assumptions made for the valuation of the impact are provided in Table D6. A number of the assumptions involved some uncertainty, so that some degree of conservatism was effected when finalising the assumptions for valuing the impact.

Table D6: Summary of Assumptions

Variable	Assumption	Source
Average annual value of Queensland mungbean and chickpea production	$264 million	Queensland Government (2022)
Proportion of production assumed stored on farm	60%	Queensland Government (2018)
Average annual value of Queensland mungbean and chickpea production that is stored on farm before sale	$158.4 million	$264 million x 60%
Adoption: Maximum proportion of chickpea and mungbean production that is stored before sale where project driven improved storage management has been implemented	20%	Agtrans Research
Percentage increase in value of pulses where improved storage management has been implemented	10%	
Increase in gross annual value of pulses where improved storage management has been implemented (full adoption)	$3.168 million	$158.4 million x 20% x 10%
Additional costs incurred due to storage management changes including additional extension effort by industry and government	40% of the increase in value of pulses due to improved storage management	Agtrans Research
Increase in net annual value of pulses where improved storage management has been implemented (full adoption)	$1.9008 million per annum	$3.168 million x (100%-40%)
First year of assumed stored pulse management change due to project (20% of final adoption)	2022	Agtrans Research
Final year of assumed stored pulse management change due to project made (100% of final adoption)	2026	
Risk factors and counterfactual		
Probability of output	100%	Agtrans Research
Probability of outcomes occurring	75%	
Probability of impacts occurring given successful outcomes	75%	
Counterfactual	Impacts assumed would not have occurred without the project funding	

Results

All benefits were expressed in 2021/22 dollar terms. All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

Investment Criteria

Tables D7 and D8 show the investment criteria estimated for different periods of benefits for the total investment and DAF investment respectively. As information on investment in the project was available only for DAF, the investment criteria in Tables D7 and D8 are the same.

Table D7: Investment Criteria for Total Investment in the Pulse Storage Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits($m)	0.00	2.82	6.63	9.61	11.95	13.78	15.22
Present value of costs ($m)	1.24	1.24	1.24	1.24	1.24	1.24	1.24
Net present value ($m)	-1.24	1.58	5.39	8.38	10.71	12.55	13.98
Benefit-cost ratio	0.00	2.28	5.36	7.77	9.66	11.14	12.30
Internal rate of return (%)	negative	19.4	29.6	31.0	31.2	31.3	31.3
MIRR (%)	n.s.	18.1	20.8	18.5	16.4	14.8	13.6

n.s. no solution

Table D8: Investment Criteria for DAF Investment in the Pulse Storage Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits($m)	0.00	2.82	6.63	9.61	11.95	13.78	15.22
Present value of costs ($m)	1.24	1.24	1.24	1.24	1.24	1.24	1.24
Net present value ($m)	-1.24	1.58	5.39	8.38	10.71	12.55	13.98
Benefit-cost ratio	0.00	2.28	5.36	7.77	9.66	11.14	12.30
Internal rate of return (%)	negative	19.4	29.6	31.0	31.2	31.3	31.3
MIRR (%)	n.s.	18.1	20.8	18.5	16.4	14.8	13.6

n.s. no solution

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of investment are shown in Figure D1.

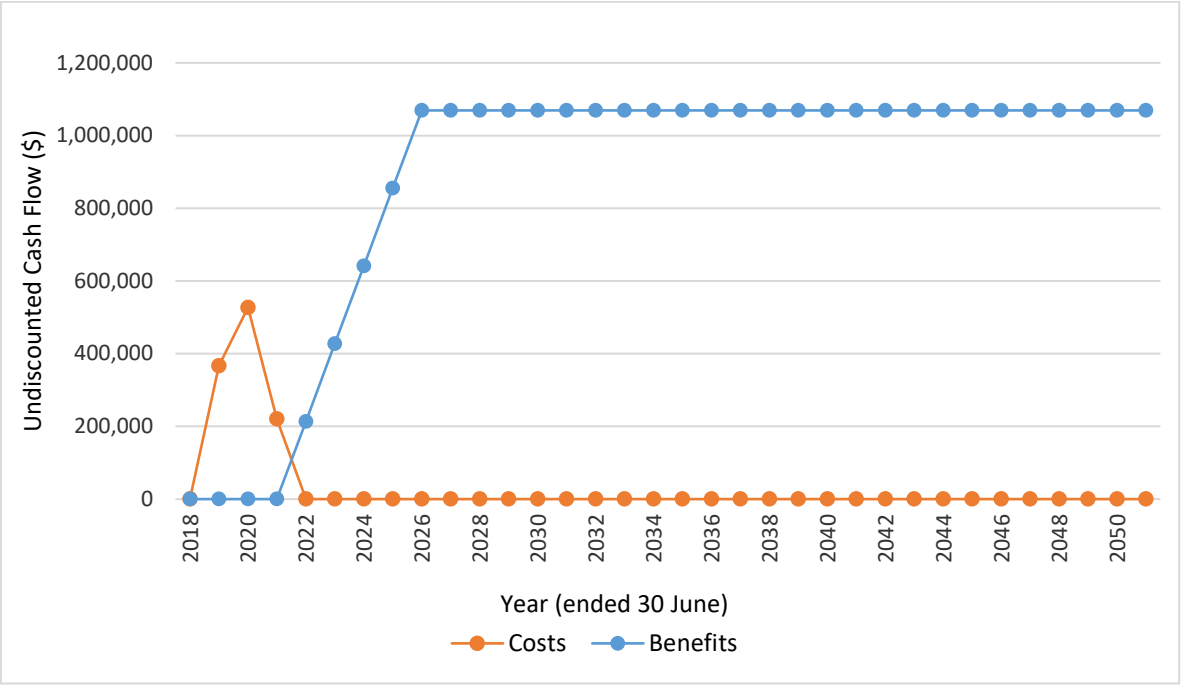

Figure D1: Annual Cash Flow of Undiscounted Total Benefits and Total Costs

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table D9 presents the results that showed a moderate sensitivity to the discount rate, largely due to the relatively long period of benefits assumed.

Table D9: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	29.94	15.22	9.13
Present value of costs ($m)	1.11	1.24	1.37
Net present value ($m)	28.82	13.98	7.77
Benefit-cost ratio	26.87	12.30	6.68

A sensitivity analysis also was carried out on the assumption regarding the maximum proportion of chickpea and mungbean production that is stored before sale where project driven improved storage management has been implemented. Results are reported in Table D10. The assumption regarding the implementation level could fall to 1.6% for the project benefits to still cover the investment costs, with all other assumptions remaining the same.

Table D10: Sensitivity to Assumed Level of Implementation of Improved Storage Methods
(Total investment, 30 years)

Investment Criteria	**Level of implementation of Improved Storage Methods for those Already Storing Pulses**		
	15%	**20% (Base)**	**25%**
Present value of benefits ($m)	11.41	15.22	19.02
Present value of costs ($m)	1.24	1.24	1.24
Net present value ($m)	10.18	13.98	17.79
Benefit-cost ratio	9.23	12.30	15.38

Confidence Ratings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made for the benefit valued, including the linkage between the research and the assumed outcomes and impacts.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table D11). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table D11: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium-Low	Medium

Coverage of benefits was assessed as Medium-Low. While there were several other potential benefits identified but not valued, the principal targeted economic impact from the project was valued.

Confidence in assumptions for the valuation was rated as Medium as some of the assumptions associated with the likely gains to pulse producers were somewhat uncertain.

Discussion and Conclusions

The foregoing assessment presents the results of an analysis of an investment in a project associated with storage management relevant to mungbean and chickpea production in Queensland and NSW. The project investment was funded by DAF, as a follow-up to a Government election commitment in 2019. The project was completed in early calendar 2022.

The assessment describes the project in a logical framework that included project objectives, activities and outputs, outcomes and impacts. Impacts were then categorised into a triple bottom line framework. The impact most amenable to valuation was then subjected to an impact valuation process.

While only one of the several impacts identified was valued, the results showed a high return on the investment. The total investment in the project of $1.24 million (present value terms) has been estimated to produce total gross benefits of $15.22 million (present value terms) and provided a net present value of $13.98 million, a benefit-cost ratio of 12.3 to 1 (using a 5% discount rate), an internal rate of return of 31.3% and a modified internal rate of return of 13.6%.

The investment criteria reported are likely to have significantly undervalued the full set of impacts delivered by the investment. The non-valued impacts included several other industry economic benefits, the environmental benefits, as well as spillover regional benefits and some technical capability and capacity impacts in pulse grain storage.

References

Australian Bureau of Statistics (2022). Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Australian Crop Report (2019). Accessed 4 May 2022 at: https://www.awe.gov.au/sites/default/files/documents/austcroprrt20191203_v1.0.0.pdf

Australian Grain Yearbook (2022), Greenmount Press.

Australian Mungbean Association (2022), Accessed April 2022 at http://www.mungbean.org.au/

CRRDC (2018), Cross-RDC Impact Assessment Program: Guidelines, Updated April 2018 – Version 2, April 2018, CRRDC, Canberra. http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Queensland Government (2018) Pulse Storage Election Commitment. Accessed 4 May 2022 at: https://statements.qld.gov.au/statements/94461#:~:text=Queensland%20researchers%20have%20developed%20Australia's,dollar%20chickpea%20and%20pulses%20industry

Queensland Government (2022) New Guide Boost to $264 million Queensland Industry. Accessed 4 May 2022 at https://statements.qld.gov.au/statements/94461#:~:text=Queensland%20researchers%20have%20developed%20Australia's,dollar%20chickpea%20and%20pulses%20industry

Queensland Government. (2022, June 28). Strategic Plan 2021-2025. Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Appendix E: An Impact Assessment of Investment in Mango Breeding: Development of the R2E2 and Calypso Varieties

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Ian Bally, Senior Principal Horticulturalist, Queensland Department of Agriculture and Fisheries

Gary Hopewell, Business Manager Horticulture and Forestry Sciences, Queensland Department of Agriculture and Fisheries

John Walsh, Calypso Mango grower, Bundaberg, Queensland

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
GDP	Gross Domestic Product
KP	Kensington Pride
PBR	Plant Breeders Rights
QLD	Queensland
MIRR	Modified Internal Rate of Return
R&D	Research and Development
RD&E	Research, Development and Extension
US	United States of America

Executive Summary

The Queensland Department of Agriculture and Fisheries (DAF) and grower partner investment in breeding the R2E2 and Calypso mango varieties has delivered outstanding results for the Australian mango industry. Together, these two varieties account for a higher share of production and generate superior profit to Kensington Pride. The Kensington Pride variety had been the industry's staple since the early 1960s.

R2E2 and Calypso grow on compact easily harvested trees, are high yielding, and produce well-coloured firm fruit that are more easily transported through the supply chain. Fruit from the two DAF-developed varieties offer retailers longer shelf-life and extension of the number of months each year that Australian mangoes are available to consumers. Both varieties also have been successful in the export market.

The total investment in development of the R2E2 and Calypso varieties by all contributors was $23.18 million (present value terms) and has been estimated to produce total gross benefits of $285.53 million (present value terms) providing a net present value of $262.36 million, a benefit-cost ratio of 12.3 to 1 (over 30 years using a 5% discount rate), an internal rate of return of 10.5% and a modified internal rate of return of 10.4%.

Results from this impact assessment are broadly similar to those estimated in a 2011 investment analysis of the Calypso Mango that reported an estimated benefit-cost ratio of 9.5 to 1. The positive results demonstrate that the investment in mango breeding has delivered benefits for the Australian mango industry. The investment should be viewed favourably by DAF, DAF funding partners, and mango industry stakeholders.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 5 (Mango Breeding Program R2E2/Calypso). The investment included mango breeding and development of the R2E2 and Calypso mango varieties and was funded over the period 1977/78 to 1990/91 for the R2E2 variety and 1995/96 to approximately 2003/04 for Calypso.

Method

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 includes both qualitative and quantitative assessment components that are in accord with the impact assessment guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

Mangoes are grown commercially throughout northern Australia and are consumed fresh, in the domestic market (85% of production), processed in Australia (4%), and exported (11%). Historically the industry has been based on the Kensington Pride (KP) variety. However, KP yields are variable, the trees grow excessively vigorous, and the fruit is poorly coloured, soft and difficult to transport through the supply chain. New varieties have been bred by DAF to address some of the limitations of KP.

R2E2

The R2E2 variety was developed by DAF in the Bowen Horticultural Research Station in the late 1970s and early 1980s. The planting of a monoembryonic selection trial that produced R2E2 at the Bowen Horticultural Research Station occurred in 1977. The first cropping of R2E2 and its selection as a superior variety occurred in 1982. In 1984, R2E2 was planted on the property of Bruno Predabon in the Burdekin. This was the variety's first commercial planting. R2E2 was selected by Ian Bally, Ross Wright, and Peter Beal as a seedling progeny of the Florida variety Kent. R2E2 takes its name from the row and position in the field in which the original tree was grown. The R2E2 variety was officially released as a public domain variety in the early 1990s[2] and commercially planted at scale in the late 1990s. R2E2 is a mid-season mango with large, highly coloured fruit. It introduced large fruit to the domestic market. R2E2 has gained wide acceptance throughout all mango-growing regions and is the third most popular variety grown in Australia (See Table E1 below). R2E2 has a long shelf-life and is sought after in export markets. R2E2 has accounted for up to 70% of all mangoes exported from Australia (Ian Bally, pers. comm., 2022).

Calypso

The breeding of B74, trademarked as Calypso, commenced in the mid-1990s on the Childers farm of John and Janet Dorrian, who provided land and management resources for the breeding program, and Dr Tony Whiley of DAF who provided technical support. Dr Whiley realised that growing KP in the subtropics was not commercially sustainable as KP's production performance was too irregular. The resulting Calypso variety was first commercially planted in 2004 and was one of the first mango varieties covered by Plant Breeders Rights (PBR) in Australia[3]. It is also covered by a United States (US) Plant Patent in the United States of America. The variety is owned jointly by the Dorrians and the State of QLD. Royalties from Calypso have been a significant source of income for DAF. Perfection Fresh Australia has an exclusive license to market Calypso in Australia and in international territories. In addition to the Intellectual Property held in the PBR and US Plant Patent, the Perfection Fresh Australia licence includes registered Trademarks for "Calypso" and "Calypso Mango" in various jurisdictions. Calypso is a mid- to late-season variety, produces a higher average yield than KP, has similar production costs, and an appealing colour and aroma. Calypso's high yield and pack-out rate has delivered superior profit for growers who have access to the variety. The fruit is firmer than other varieties and therefore provides greater robustness during packing and transportation.

Table E1 below shows Australian mango production by variety. Together, R2E2 and Calypso account for approximately 44% of production. KP is less profitable than the new varieties for growers and has a shorter shelf-life for retailers. KP is also less visually appealing for consumers. However, the flavour of KP

[2] The variety was already being grown commercially by this data on many farms, but this was the official date of release as per earlier statement "The first cropping of R2E2 and its selection as a superior variety occurred in 1982. In 1984, R2E2 was planted on the property of Bruno Predabon in the Burdekin" (Ian Bally, Senior Principal Horticulturalist, QLD DAF, pers. Comm., July 2022).

[3] Honey Gold was granted PBR before B74 Calypso, but B74 Calypso's application / registration was received by IP Australia earlier (Ian Bally, Senior Principal Horticulturalist, QLD DAF, pers. Comm., July 2022).

is still popular with some consumers (Ian Bally and Gary Hopewell, pers. comm., 2022). In some instances, KP will have been substituted on farm by the new varieties, in others, the new varieties will have been part of a planned expansion due to growth in the mango market (Strahan and Pratt, 2011). The addition of R2E2 and Calypso has extended the supply window for Australian mangoes and added to the length of time mangoes are available to Australian and international consumers.

Table E1: Australian Mango Production by Variety 2020

Variety	**Share of production (%)**	**Number of 7kg trays produced**
Kensington pride	43	4,424,209
Calypso	25	2,572,214
R2E2	19	1,954,883
Honey Gold	8	823,109
Other (Keitt, Tommy Atkins, Palmer, and Nam Dok Mai)	5	514,443
Total	**100**	**10,288,857**

Source: Mango Strategic Investment Plan 2022-2026 and consultant analysis

Project Details

Summary

Project Code: not applicable

Title: *Mango breeding and development of the R2E2 and Calypso varieties*

Research Organisation: DAF

Principal Investigators: Ian Bally, Senior Principal Horticulturalist, DAF and Gary Hopewell, Business Manager, DAF

Period of Funding: July 1977 to June 2004 (approximately)

Objectives

A series of investments made by DAF, its predecessor organisations and industry partners aimed to provide mango growers with a more profitable mango variety as an alternative to KP.

Logical Framework

Table E2 describes the investment in mango breeding and development in a logical framework and includes a summary of project activities, outputs, actual and expected outputs, and potential impacts associated with the outcomes.

Table E2: Logical Framework for Mango Breeding and Development of the R2E2 and Calypso Varieties

Activities	• Preparation of land for the planting of mango breeding trials. Land was prepared in 1977/78 for the program that would identify R2E2 at the DAF Bowen Horticultural Research Station. • Land was prepared in 1995/96 on the farm of John and Janet Dorrian, Childers, QLD for the program that would identify Calypso. • DAF staff were responsible for selection of mango genetics and their delivery via an open pollinated breeding program. Seedlings were grown at DAF research stations and each year a new batch were planted. At Childers, a total of 10,000 seedlings were grown out and evaluated over the course of the program. • Mango breeding trial sites required ongoing maintenance for approximately ten years. Activities included fertilisation, chemical application, irrigation, and weed management. These tasks were performed by DAF personnel at Bowen and by the Dorrian family at Childers. • Promising lines were identified and evaluated using KP as a benchmark. Gains in yield, yield consistency, fruit shape, size, colour, aroma, and firmness were recorded along with a requirement for a compact tree and improved resistance to diseases such as bacterial black spot and anthracnose. • R2E2 and Calypso were identified as promising varieties and plant numbers were expanded prior to commercial release. The R2E2 variety was first planted commercially in the late 1980s and Calypso in 2004. • New varieties were promoted through industry publications, DAF field days and the holder of the Calypso licence (originally One Harvest and now Perfection Fresh). • R2E2 was made available to all nurseries and growers interested in planting the variety. • Calypso was exclusively licenced via a closed-loop marketing system. Growers are required to sell produce through the licensee and pay a marketing levy for promotion of the variety. Growers must also use the registered Calypso/Calypso Mango trademarks.

Outputs	• Relevant research reports, publications, and industry communication materials. • A licencing agreement to commercialise and develop the Calypso variety on an exclusive basis. • Identification of two mango varieties with traits that are superior to KP.
Outcomes	• Industry adoption of superior, DAF-bred mango varieties R2E2 and Calypso.
Impacts	• An increase in mango grower net profit with a partial shift from KP to the DAF-bred varieties (R2E2 and Calypso). Both varieties generate higher average saleable yields. • Increased mango breeder capacity in selecting and delivering superior varieties. • Increased income in regional Australia associated with a more profitable and sustainable mango industry.

Source: DAF project documentation and consultation with project personnel.

Nominal Investment

R2E2

DAF advice was that there were no contract records or financial statements available on the cost of R2E2 breeding (Gary Hopewell, Business Manager DAF, pers. comm., April 2022). However, the cost of developing R2E2 was low – approximately 20% of Ian Bally's time as a technical officer grade 2 technician with a lesser investment of Ross Wright's time as a plant breeder plus assistance from Peter Beal (plant breeder) who organised the planting of the early selection trial (Ian Bally, pers. comm., 2022). These DAF costs were incurred from the late 1970s through to commercial release of the R2E2 variety in 1991. A nominal wage cost consistent with wage payments in the 1980s, including on-costs, of $39,000 per annum for all three researchers therefore was assumed. An allowance was also made for the opportunity cost of land used for the breeding program (a nominal cost of $6,000 per annum). Grower investment in the breeding of R2E2 included on-farm trials from 1984. An allowance of $15,000 per annum was assumed for grower trial labour and the opportunity cost of production land. Table E3 shows the total annual investment made in the breeding of R2E2.

Table E3: Total Investment in Breeding the R2E2 Mango Variety (nominal dollar terms)

Year ended 30 June	DAF ($)	Growers/ Others ($)	Total ($)
1978	45,000	0	45,000
1979	45,000	0	45,000
1980	45,000	0	45,000
1981	45,000	0	45,000
1982	45,000	0	45,000
1983	45,000	0	45,000
1984	45,000	15,000	60,000
1985	45,000	15,000	60,000
1986	45,000	15,000	60,000
1987	45,000	15,000	60,000
1988	45,000	15,000	60,000
1989	45,000	15,000	60,000
1990	45,000	15,000	60,000
1991	45,000	15,000	60,000
Totals	**630,000**	**120,000**	**750,000**

Source: Analyst assumptions using advice from Ian Bally (pers. comm., 2022)

Calypso

All costs incurred by DAF and the Dorrian family are relevant to estimation of the cost of breeding Calypso. These costs included labour costs incurred by the Dorrians ($60,000 per annum), and the opportunity cost of land that was devoted to mango breeding ($6,000 per annum). DAF costs included staff time and on-costs to meet corporate expenses ($66,000 per annum) (Strahan and Pratt, 2011). Breeding costs were incurred from 1996 to 2004. Table E4 shows the total annual investment made in the breeding of Calypso.

Table E4: Total Investment in Breeding the Calypso Mango Variety (nominal dollar terms)

Year ended 30 June	DAF ($)	John & Janet Dorrian ($)	Total ($)
1996	66,000	66,000	132,000
1997	66,000	66,000	132,000
1998	66,000	66,000	132,000
1999	66,000	66,000	132,000
2000	66,000	66,000	132,000
2001	66,000	66,000	132,000
2002	66,000	66,000	132,000
2003	66,000	66,000	132,000
2004	66,000	66,000	132,000
Totals	**594,000**	**594,000**	**1,188,000**

Source: Strathan and Pratt (2011), as well as Gary Hopewell (pers. comm., 2022)

Management and Administration Costs

For the DAF investment, the management and administration costs for the project were assumed to already be included in the nominal dollar amounts appearing in Table E3 and E4. The salary multiplier that had been used by DAF was a 2.85 multiplier for salaries contributed by DAF (Wayne Hall, pers. comm., 2017).

For the other investment, it was assumed that the investment costs reported included any management and administration costs. Therefore, a management cost multiplier of 1.0 was applied to all the other financial contributions shown in Table E3 and E4.

Real Investment and Extension Costs

For the purposes of the analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2022). DAF has not incurred any costs for the R2E2 variety since release of the variety in 1991 other than mentioning it in some extension material (Ian Bally, pers. comm., 2022). Promotion costs for Calypso were: 2005, launch, promotions, samples $79,604; 2006 promotions $74,731; and 2007 promotions $199,549 (Gary Hopewell, pers. comm., 2022).

Impacts

Table E5 provides a summary of the principal types of actual or potential impacts from investment in the breeding of the R2E2 and Calypso varieties. Impacts have been taken from Table E2 and categorised using a triple bottom line framework into economic, environmental, and social impact types.

Table E5: Principal Impact Types from Investment in Mango Breeding and Development of R2E2 and Calypso Varieties

Economic	• An increase in mango grower net profit with a partial shift from KP to the DAF-bred varieties (R2E2 and Calypso). Both varieties generate higher average saleable yields.
Environmental	• Nil.
Social	• Increased mango breeder capacity in selecting and delivering superior varieties. • Increased income in regional Australia associated with a more profitable and sustainable mango industry.

Public versus Private Impacts

The project generated both private and public impacts. The principal private impact is an increase in mango grower net profit with a partial shift from KP to the DAF-bred varieties R2E2 and Calypso. Public impacts include social benefits associated with enhanced breeder capacity and spill-over income and employment benefits in regional communities.

Distribution of Private Impacts

The private impacts from the investment will be shared along the mango supply chain with growers, packers, transporters, wholesalers, exporters, and retailers all realising some of the potential impacts. Benefits have also been realised by Perfection Fresh Australia which has an exclusive license and the sole rights to market Calypso. The share of benefits retained by each link in the supply chain will depend on ruling short- and long-term supply and demand elasticities.

Impacts on Other Australian Industries

Investment in mango breeding will only benefit the mango industry. However, it is noted that breeder capacity developed as part of the project may be applied to the creation of other plant varieties.

Impacts Overseas

Development of the R2E2 and Calypso varieties will benefit both overseas mango industries and overseas mango consumers. For example, Calypso is licenced for production in Peru, Mexico, China, Spain, South Africa, the Dominican Republic, and Brazil. Australian Calypso mangoes are exported for consumption in New Zealand, the US, South Korea, Canada, Europe, Hong Kong, China and the Middle East.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table E6. The DAF mango breeding project has contributed to National Science and Research Priority 1 as well as Agricultural Innovation Priority 1.

Table E6: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. **Food** – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. 2. **Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. 3. **Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. 4. **Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. 5. **Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. 6. **Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. 7. **Environmental Change** – mitigating, managing or adapting to changes in the environment. 8. **Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. 1. Australia is a trusted exporter of premium food and agricultural products by 2030. 2. Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030. 3. Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030. 4. Australia is a mature adopter, developer and exporter of digital agriculture by 2030. Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation, and decision-making around QLD's future investment are reproduced in Table E7.

The investment addressed QLD Agriculture and Food RD&E Roadmap's Strategy 1 (increase innovation and commercialisation) and 3 (support existing sector to grow and develop new business). In terms of Investment Decision Rules, the investment has had a real future impact i.e., increased mango grower profit. The investment also secured external commitment through John and Janet Dorrian.

Table E7: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The long-term investment in mango breeding has contributed to DAF Strategic Objective 1 and 2.

Case Study

The following section provides real world feedback on how the outputs of the investment have benefited the mango industry.

Case Study 1: John Walsh, Calypso Mango Grower, Bundaberg

John Walsh grows 750 ha of avocado and 89 ha of mango in his Burnett River property, Bundaberg, QLD. John's current mango variety mix is 10% KP, 40% Honey Gold and 40% Calypso. A phone interview was completed with John on 9 May 2022.

"I grow the Calypso variety because, compared to Kensington Pride, it is such a reliable, consistent yielding variety and the yields I get are high, again compared to KP. Calypso is more profitable".

"What I really like about the variety is ease of packing. Its shape is just inherently easier than KP to handle. It works really well on our grading platform and when it works well, it saves me packing time and cost".

"With Calypso we have a network of growers with the benefit of single desk marketing. We get better planning and a marketing program. Because the supply is limited, and consumers really want the fruit, we are in a stronger bargaining position with retailers. Retailers can't divide and conquer".

"As I expand my mango area, I will be planting more of the new varieties – Calypso and Honey Gold".

Valuation of Impacts

Impacts Valued

Valuation of Impact 1: Increased mango grower net profit from R2E2 and Calypso

The DAF investment has delivered two successful mango varieties that are more profitable than KP. Each of the new varieties delivers a higher sustainable yield without incurring a price discount. Potentially price premiums are available for R2E2 and certainly for Calypso. Production costs are broadly similar. However, R2E2 and Calypso may have slightly lower growing and packing costs - they are cheaper to pick given that they grow on more compact trees, and cheaper to pack given they have a "blocky" shape that may allow them to be packed into trays at less cost than KP. Gross margins were developed for KP, R2E2, and Calypso and the difference between grower returns was used to estimate the impact of the breeding investment.

Attribution of Impacts to the Project

DAF investment in breeding R2E2 and Calypso has delivered two highly successful commercial mango varieties. In addition to breeding program costs, additional costs have been incurred extending information to growers on the new varieties, launching and promoting Calypso by the exclusive licence holder, and by growers incurring the capital cost of trees of each new variety and developing variety management capacity. Consequently a 50% attribution factor has been assumed for the benefits attributable to the breeding program investment assessed.

Counterfactual

In the absence of DAF investment, it was assumed that there was a 50% likelihood that project benefits would have been generated through an alternative source e.g., purely private investment by the Dorrians, or a research partnership with Hort Innovation.

Impacts Not Valued

Two potential project impacts identified in Table E5 were not valued – increased mango breeder capacity, and increased income in regional Australia. These potential impacts were not valued as they were either deemed difficult to quantify (e.g., improved mango breeder capacity) or of low relative significance when compared to the impact that was valued (e.g., increased income in regional Australia).

Summary of Assumptions

A summary of assumptions and data sources used in the valuation of impacts is provided in Table E8 (below).

Table E8: Summary of Assumptions

Variable	Assumption	Source
Increased mango grower profit with R2E2		
Current production of R2E2	1,954,883 trays	See Table E1
Profit on R2E2 (a)	$13/tray	Analyst estimate using data from Bennett and Dickinson 2021, Mullins 2007, and Clarke and Dunmall 2019
Profit on KP (b)	$8/tray	
Net increase in profit with R2E2	$5/tray	(a) minus (b)
Year of first benefit	1995/96	Project documentation records commercial planting of R2E2 in late 1990s
Year of maximum benefit	1999/2000	R2E2 well established in the marketplace including in export markets by 2000
Increased mango grower profit with Calypso		
Current production of Calypso	2,572,214 trays	See Table E1
Profit on Calypso (a)	$15/tray	Analyst estimate using data from Bennett and Dickinson 2021, Mullins 2007, and Clarke and Dunmall 2019
Profit on KP (b)	$8/tray	
Net increase in profit with Calypso	$7/tray	(a) minus (b)
Year of first benefit	2004/2005	Project documentation records commercial planting of Calypso in 2004
Year of maximum benefit	2008/2009	Calypso well established in the marketplace by late 2000s
Assumptions common to R2E2 and Calypso		
Probability of output	100%	Valuable outputs have been delivered.
Probability of outcome	100%	R2E2 and Calypso are in commercial production
Probability of impact	100%	Market data indicates both varieties offer superior returns to KP
Attribution of impact to the project	50%	See above text
Counterfactual	50%	See above text

Results

All past costs were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP (ABS, 2022). All costs and benefits were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2003/04).

Investment Criteria

Table E9 and Table E10 show the investment criteria estimated for different periods of benefits for the total investment and the DAF investment, respectively. The present value of benefits (PVB) attributable to DAF investment only, shown in Table E9, was estimated by multiplying the total PVB by the DAF proportion of real investment (70.0%).

Table E9: Investment Criteria for Total RD&E Investment in Mango Breeding

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	48.28	100.96	157.66	202.09	236.89	264.17	285.53
Present value of costs ($m)	23.18	23.18	23.18	23.18	23.18	23.18	23.18
Net present value ($m)	25.10	77.79	134.49	178.91	213.72	240.99	262.36
Benefit-cost ratio (BCR)	2.08	4.36	6.80	8.72	10.22	11.40	12.32
Internal rate of return (IRR) (%)	5.2	8.4	9.7	10.2	10.4	10.5	10.5
Modified IRR (%)	8.8	11.0	11.6	11.5	11.2	10.8	10.4

Table E10: Investment Criteria for DAF RD&E Investment in Mango Breeding

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	33.79	70.68	110.37	141.46	165.83	184.92	199.88
Present value of costs ($m)	18.15	18.15	18.15	18.15	18.15	18.15	18.15
Net present value ($m)	15.64	52.52	92.21	123.31	147.68	166.77	181.73
Benefit-cost ratio	1.86	3.89	6.08	7.79	9.14	10.19	11.01
Internal rate of return (IRR) (%)	4.0	7.2	8.5	9.0	9.2	9.3	9.4
Modified IRR (%)	7.9	10.2	10.9	10.9	10.6	10.3	10.0

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of investment are shown in Figure E1.

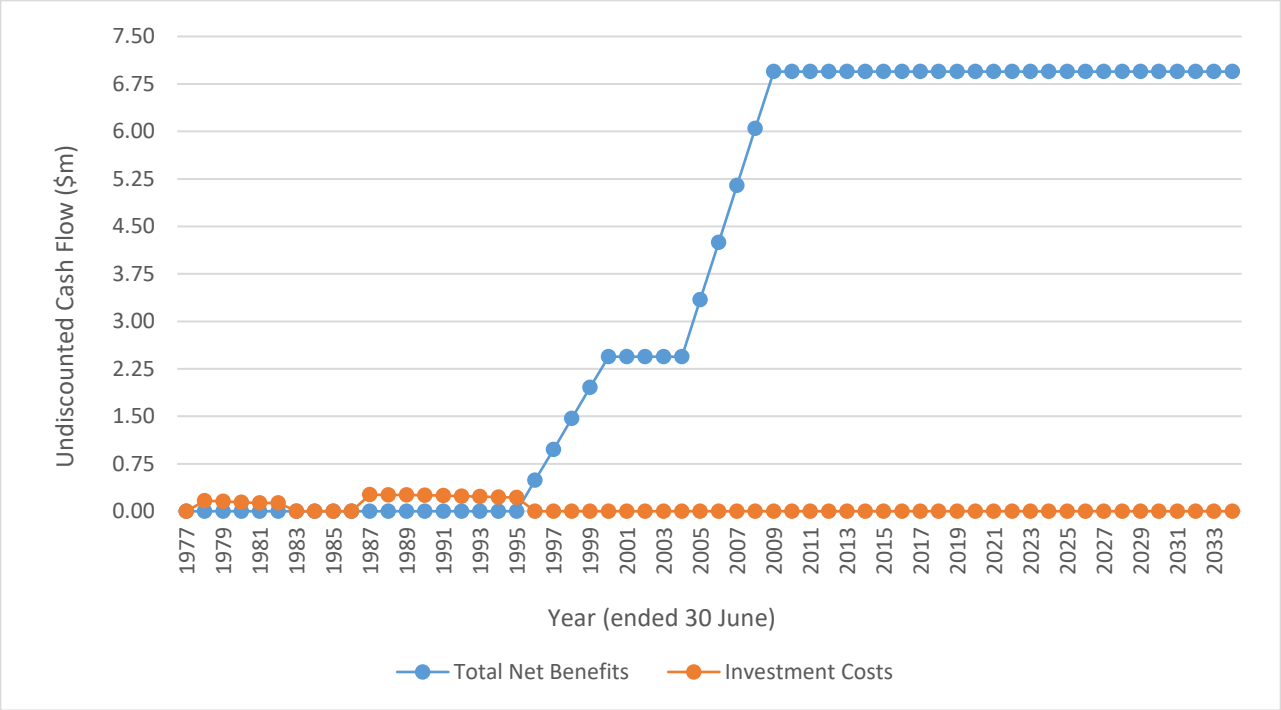

Figure E1: Annual Cash Flow of Undiscounted Total Net Benefits and Total Investment Costs

Sensitivity Analyses

Sensitivity analyses were carried out on variables that were (a) considered key drivers of the investment criteria and/or (b) considered the most uncertain. The analyses were performed for the total proposed project investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

A sensitivity analysis was carried out on the discount rate. Results are reported in Table E11. The results show that the investment criteria are highly sensitive to the discount rate. This is due to the unusually long duration of investment which commenced, for R2E2, in 1977/78.

Table E11: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	216.45	285.53	453.76
Present value of costs ($m)	4.72	23.18	122.65
Net present value ($m)	211.73	262.36	331.11
Benefit-cost ratio	45.86	12.32	3.70

A sensitivity analysis was then completed on the assumed net profit of R2E2 and Calypso over and above that of KP (Table E12). Results show that profit would need to fall to approximately $0.45/tray for R2E2 and $0.60/tray for Calypso before the project would approach break-even i.e., project costs equal project benefits.

Table E12: Sensitivity to Net Profit on R2E2 and Calypso
(Total investment, 30 years)

Investment Criteria	**Grower Profit on R2E2 and Calypso Vs KP**		
	R2E2 = $0.45/tray Calypso = $0.60/tray	**R2E2 = $2.50/tray Calypso = $3.50/tray**	**R2E2 = $5.00/tray Calypso = $7.00/tray (base)**
Present value of benefits ($m)	25.07	142.77	285.53
Present value of costs ($m)	23.18	23.18	23.18
Net present value ($m)	1.89	119.59	262.36
Benefit-cost ratio	1.08	6.16	12.32

Confidence Ratings and other Findings

The investment analysis results are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table E13). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table E13: Confidence in Analysis of Project

Coverage of Benefits	**Confidence in Assumptions**
High	High

Coverage of benefits was assessed as High. The principal benefit, increased mango grower net profit from growing R2E2 and Calypso was quantified.

Confidence in assumptions was also rated as High. Both R2E2 and Calypso are established in the market and accurate price and quantity information could be sourced and applied to the analysis.

Discussion and Conclusions

DAF and grower partner investment in breeding R2E2 and Calypso has delivered outstanding results for the Australian mango industry. Together, these two varieties account for a higher share of production and generate superior profit to KP. The KP variety had been the industry's staple since the early 1960s.

R2E2 and Calypso grow on compact easily harvested trees, are high yielding, and produce well-coloured firm fruit that are more easily transported through the supply chain. Fruit from the two DAF-developed varieties offer retailers longer shelf-life and an extension of the number of months each year that Australian mangoes are available to consumers. Both varieties also have been successful in the export market.

The total investment in breeding and development of the R2E2 and Calypso varieties by all contributors was $23.18 million (present value terms) and has been estimated to produce total expected net benefits of $285.53 million (present value terms) providing a net present value of $262.36 million, a benefit-cost ratio of 12.3 to 1, an internal rate of return of 10.5% and a MIRR of 10.4% (over 30 years using a 5% discount rate).

Results from this impact assessment are broadly similar to those estimated by Strahan and Pratt (2011) from an investment analysis of the Calypso Mango. Strahan and Pratt (2011) estimated a benefit-cost ratio of 9.5 to 1. The positive results demonstrate that the investment in mango breeding has delivered benefits for the Australian mango industry. The investment should be viewed favourably by DAF, DAF funding partners, and mango industry stakeholders.

References

Anon (undated) History of Mango Genetic Improvement in Queensland – Calendar of Events

Australian Bureau of Statistics. (2022, March 02). Australian National Accounts: National Income, Expenditure and Product Quarterly estimates of key economic flows in Australia, including gross domestic product (GDP), consumption, investment, income and saving. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Bennett, D and Dickinson, G (2021) Economic Case Study of Intensive Mango Systems: A comparison of the profit of conventional (low, medium, and high density) and teellis (high density) mango canopy systems in North QLD based on early trial results.

Clarke, M and Dunmall, T (2019) Economic Analysis: Additional Grower and Industry Led Tropical Plant Pest Surveillance. Report for Plant Health Australia, October 2019.

Commonwealth of Australia. (2015). Agricultural Competitiveness White Paper. Canberra: Commonwealth of Australia. Retrieved from http://agwhitepaper.agriculture.gov.au/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf

CRRDC (2018) Council of Rural Research and Development Corporations. Cross-RDC Impact Assessment Program: Guidelines. Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Hort Innovation (2021). Mango Strategic Investment Plan 2022-2026. Accessed at https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-2022-2026-pdfs/hort-innovation-sip-2022-26-mango.pdf

Mullins, T (2007) Gross Margin for Mango (Kensington Pride – Full Production) – Irrigated Dry Tropics. Update of Billl Johnston (developed 1998).

Office of the Chief Scientist. (2015). Strategic Science and Research Priorities. Canberra: Commonwealth of Australia. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/STRATEGIC-SCIENCE-AND-RESEARCH-PRIORITIES_181214web.pdf

Office of the Chief Scientist, Queensland Government (2015) Revised Queensland Science and Research Priorities, accessed 17 February 2019 at: https://www.chiefscientist.qld.gov.au/documents/strategy-priorities/qld-science-n-research-priorities-2015-2016.pdf

Queensland Government. (2022, June 28). Strategic Plan 2021-2025. Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc

Strathan, R and Pratt, R (2011). Investment Analysis of the Development of the Calypso Mango Variety.

Appendix F: An Impact Assessment of Investment in Building the Resilience and On-Farm Capacity of the Australian Production Nursery Industry - Hort Innovation Project NY15002

Acknowledgments

ACRE Economics Pty Ltd, in association with Agtrans Pty Ltd and AgEconPlus Pty Ltd, would like to thank Wayne Hall (Executive Director) and Lynda Bull (Executive Officer) of Agri-Science Queensland at the Queensland Department of Agriculture and Fisheries for facilitating contact with relevant project personnel and for their guidance and feedback throughout the impact assessment process.

Other specific acknowledgments for contributions to the evaluation process are made to:

Andrew Manners, Principal Entomologist, Horticulture and Forestry Science, Queensland Department of Agriculture and Fisheries

Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Queensland Department of Agriculture and Fisheries
EPP	Emergency Plant Pest
FMS	Farm Management System
GIA	Greenlife Industry Australia
GVP	Gross Value of production
HACCP	Hazard Analysis Critical Control Point
Hort Innovation	Horticulture Innovation Australia Ltd
MIRR	Modified Internal Rate of Return
NGIQ	Nursery and Garden Industry Queensland
NGIs	Nursery and Garden Industry Groups
NIASA	Nursery Industry Accreditation Scheme Australia
PHA	Plant Health Australia
PVB	Present Value of Benefits
QLD	Queensland
RD&E	Research, Development, and Extension
RDC	Research and Development Corporation
TFE	Technical Feasibility of Eradication

Executive Summary

This report presents the assessment process, analysis, and associated findings of an impact assessment of the Queensland Department of Agriculture and Fisheries' (DAF) investment in a research, development, and extension (RD&E) project titled: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry* (Horticulture Innovation Australia Ltd (Hort Innovation) Project NY15002) funded over the period January 2016 to December 2020.

The impact assessment followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations (RDCs), Cooperative Research Centres, State Departments of Agriculture, and some universities. The evaluation process followed an input to impact continuum and involved both qualitative and quantitative analysis components. The impact assessment approach used was in accord with the current guidelines of the Council of Rural RDCs.

The investment in Project NY15002 delivered a range of nursery industry biosecurity information, resources, training and education activities, and monitoring, diagnostics, and technical services to production nursery industry stakeholders. The project activities and outputs were well received by participants with a significant proportion of those who engaged in training and education activities indicating intention to make positive practice changes as a result of the project. Further, the project has contributed to increased grower awareness, understanding, and utilisation of pest and disease monitoring, diagnostics, and other biosecurity services. This was evident through substantial increases in the amount and regularity of submission of suspect samples to the DAF nursery industry monitoring and surveillance team.

Through these outputs and outcomes, the investment in Hort Innovation Project NY15002 has led to a number of positive potential impacts for the production nursery and broader community. Potential impacts from the investment included:

- A net increased productivity and profitability for some production nursery enterprises because of:
  - Improved on-farm pest and disease management practices, and
  - Improved awareness and use of pest and disease monitoring, diagnostics, and technical advice from government agencies.
- Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases.
- Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management.

The total investment in Project NY15002 was estimated at $3.57 million (present value terms) and produced total expected net benefits of approximately $14.46 million (present value terms). This gave an estimated net present value of $10.89 million, a benefit-cost ratio of 4.1 to 1, an internal rate of return of 12.6% and a MIRR of 9.2% (over 30 years, using a 5% discount rate and 5% reinvestment rate for the MIRR).

Overall, the assessment of investment in Hort Innovation Project NY15002: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry* found that the project produced useful outputs that were well received by end-users and other stakeholders. Also, the project has, and is likely to, deliver positive impacts for Australian production nurseries and other dependent industries, as well as the broader Australian community. The investment should be viewed favourably by DAF, DAF funding partners, and nursery industry stakeholders.

Introduction

The Queensland Department of Agriculture and Fisheries (DAF) is committed to delivering positive impacts for Queensland (QLD) agriculture through ongoing investment in research, development, and extension (RD&E) guided by the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). To determine the impacts of past and current RD&E, DAF required a series of impact assessments to be carried out on a number of investments in the Agri-Science QLD RD&E portfolio. The assessments were required to demonstrate the net benefits of DAF RD&E investments to industry, funding partners, and the broader Queensland community, provide accountability and contribute to Government RD&E resource allocation best practice, and provide input to DAF performance and annual reporting.

In 2021/22, DAF identified six RD&E investments for evaluation. The six RD&E investments were:

1. Legume Learnings in the Coastal Landscape
2. Fish Attracting Structures
3. Vegetable Exports: managing the transition from air freight to sea freight in response to COVID-19
4. Grains Storage Best Management Practice
5. Mango Breeding Program (R2E2/Calypso)
6. Building Capacity for Nursery Biosecurity

This report presents the assessment process, analysis, and associated findings of an impact assessment of investment 6 (Building Capacity for Nursery Biosecurity). The investment included a single RD&E project funded over the period January 2016 to December 2020 titled: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry.*

Method

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 includes both qualitative and quantitative assessment components that are in accord with the impact assessment guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process followed an input to impact continuum and involved identifying and briefly describing project objectives, activities, outputs, actual and expected outcomes, and any actual and/or potential impacts associated with project outcomes. The principal economic, environmental, and social impacts then were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision to value an impact identified was based on:

- Data availability and information necessary to form credible valuation assumptions,
- The complexity of the relevant valuation methods applicable given project resources,
- The likely magnitude of the impact and/or the expected relative value of the impact compared to other impacts identified, and
- The strength of the linkages between the RD&E investment and the impact identified.

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. 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 the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

The Australian nursery industry supports a number of production sectors including urban horticulture, food supply via fruit and vegetable cropping, fibre production through forestry, and the environment under land care and revegetation. Endemic and exotic pests and diseases represent a major threat to the health, productivity, and profitability of the Australian nursery industry, as well as the industries it supports. The nursery industry is particularly vulnerable compared to other horticultural industries, mainly because of the diversity of plant species and the multitude of pathogens and pests associated with these hosts. Further, the extensive domestic and international movement of nursery stock through commercial trade provides an ideal pathway for the spread of pests and diseases.

A previous project, Horticulture Innovation Australia Ltd (Hort Innovation) Project NY11001: *Plant health, biosecurity, risk management and capacity building for the nursery industry*, provided a high standard of biosecurity support to the Australian nursery industry through a combination of training, resource development, diagnostics, and technical advice. Project NY11001 was well received by state-based Nursery and Garden Industry groups (NGIs), production nurseries and allied trade partners.

Project NY15002, led and co-funded by DAF, built on the success of Project NT11001 with a greater focus on biosecurity in a number of key areas. This included the development of new contingency plans, updating and adding to existing contingency plans, developing web-based resources, providing industry training, and developing emergency permit applications for in the event of the detection of critical Emergency Plant Pests (EPPs). The project also was funded to support the industry biosecurity portfolio manager during EPP incursions and to conduct EPP simulations exercises.

Project Details

Summary

Project Code: Hort Innovation Project NY15002
Title: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry*
Research Organisation: Department of Agriculture and Fisheries Queensland
Principal Investigator: Andrew Manners, Senior Entomologist, DAF
Period of Funding: January 2016 to December 2020

Objectives

There were two main aspects to Project NY15002, these were:

1. Assist the nursery industry to build biosecurity preparedness and planning, both at an industry and on-farm perspective.
2. Assist production nurseries to identify and manage pests and diseases more efficiently.

Logical Framework

Table F1 describes the investment in Project NY15002 in a logical framework and includes a summary of project activities, outputs, actual and expected outputs, and potential impacts associated with the outcomes.

Table F1: Logical Framework for Hort Innovation Project NY15002

Activities	<u>Building Biosecurity Preparedness and Planning:</u> • A major, national biosecurity exercise was undertaken to simulate the incursion of *Xylella fastidiosa*, the number one National Priority Plant Pest in Australia. • This aspect of the project was completed in collaboration with Plant Health Australia (PHA) and a committee of industry and state government biosecurity representatives. • The exercise, named 'Exercise Fastidious', was completed as a two-day exercise with a diverse group of participants including state and federal jurisdictions, Australian industry representatives and New Zealand (NZ) government and industry representatives. • Existing contingency plans were reviewed and updated as required. • This included significant additions to the response sections of the plans specific to each pest as well as updating other sections as appropriate (e.g. the biology and diagnostics). • In addition, new contingency plans were written over the course of the project. • These documents will assist biosecurity organisations and industry respond to other pests in the event that they are detected in Australia. • Support was provided to the nursery industry's National Biosecurity Officer who assists during EPP incursions by providing expertise in the areas of pest biology, host range, and pest impacts. <u>Identify and Manage Pests and Diseases More Efficiently:</u> • This aspect of the project was achieved through improved diagnostic capacity to enhance grower preparedness, contributions to the industry web-based plant health and biosecurity resource material and training through national grower workshops and webinars. • The project team provided pest and disease diagnostic work for the Australian nursery industry under the umbrella of DAF's diagnostic service, Grow Help Australia.

	• All nurseries accredited under the Nursery Industry Accreditation Scheme Australia (NIASA) received 10 free samples per year. • All production nurseries received a significant discount, providing identification of the problem and specific recommendations suited to their business for the cost of about $85 per sample. • Most reports included colour photographs of symptoms and relevant pests/diseases detected to assist nursery managers and staff in the recognition of diagnosed problems. • De-identified photographs taken from diagnostic samples were used in fact sheets and other web-based resource materials. • The project team developed a suite of plant health and biosecurity resource materials to underpin activities within a related project, NY15004 (*National Nursery Industry Biosecurity Project*), and compliment NIASA and BioSecure Hazard Analysis Critical Control Point (HACCP) programs. • These materials, developed in collaboration with the project reference group, included pest and disease factsheets, nursery papers and pest management plans, as well as images and descriptions of pests and diseases for inclusion an industry web-based information package (Pest ID tool). • The project team delivered on-farm field days and industry workshops on pests, diseases, and biosecurity preparedness in every state/territory each year of the project. • A total of seven workshops per year were expected, but were not possible in 2020 because of COVID-19. • Workshops focused on the identification and management of key nursery pest and disease groups, and were framed around current plant health and biosecurity resource material available through industry and government sources, such as BioSecure HACCP and NIASA Best Management Practice Guidelines. • Webinars were completed in each year of the project. Each one-hour webinar focused on a specific area, e.g. management of leaf spots, root rots, leaf feeding insects etc. • Four webinars were completed in the first year of the project. The project reference group decided to complete two webinars per year thereafter and replace two webinars with one factsheet. However, additional webinars were also completed in 2020 to replace workshops.
Outputs	• Exercise fastidious was completed. The two-day exercise had 59 attendees. • Diagnostic and technical support was provided to the production nursery industry. • Technical support in relation to 10 exotic pests was required during the life of the project. Many additional pests were reported during this time, but assistance was not required from the project team. • Over 2,300 samples were received from NIASA and non-NIASA production nurseries across every state in Australia. • Over the life of the project the most common pests diagnosed were from the genera *Pythium*, *Phytopythium*, *Fusarium*, *Phytophthora* and *Colletotrichum*. • A total of 22 fact sheets on various pests, diseases and disorders were completed. All fact sheets completed are available on the production nursery farm management system (FMS) website. • One nursery paper was completed per year of the project. These were strictly 4-page documents that were communicated to industry via their communication channels and the Greenlife Industry Australia (GIA) website. • Nine pest management plans were produced over the life of the project.

	• Seven contingency plans against specific pest threats were completed and an additional plan is being completed in collaboration with a Hort Innovation funded area wide management project (VG16086). • All pest management plans and contingency plans are available on the nursery production FMS website. • A total of 28 workshops were completed with 615 total attendees. • Further, a total of 14 webinars were completed over the life of the project with 263 total attendees and over 10,000 total subsequent views (Andrew Manners, pers. comm., 2022). • Some webinars have been viewed more than others ranging from about 1 to 20 views per week. All webinars are able to viewed on the GIA YouTube channel. • Also, DAF completed 75 full page factsheets and provided approximately 1,000 photographs for inclusion in the Pest ID tool database. • The QLD state industry group, Nursery and Garden Industry Queensland (NGIQ), was sub-contracted to administer the database and complete additional pages as required.
Actual and Expected Outcomes	• Workshop evaluations were completed after each project workshop. • 50-60% of workshop attendees that completed the evaluation indicated that they would make at least one positive change as a result of the workshop. • Long term evaluation (at least one year after attending a workshop) indicated a number of common areas where attendees had made a change as a result of workshops: (a) Increased crop monitoring (b) Improved ability to triage sick plants (c) Reduced weed populations (d) Improved hygiene practices (e) Accessed nursery resources more frequently (f) Become more proactive, not as reactive (g) Increased use of biological control (h) Decreased pest/disease incidence, including fewer discarded plants (i) Improvements in plant health • In general, 15-20% of webinar attendees completed follow-up surveys. • Respondents indicated that the webinars increased their knowledge of the webinar topic to a high degree and were consistently relevant to their business. • As a result of attending the webinars, respondents indicated that they would make changes to nursery practices including: (a) Improving plant health monitoring (b) Increasing the number of hygiene and cultural practices to reduce pest pressure and need to apply pesticides (c) Completing small-scale, in-field trials to improve crop growth/pest management (d) Choosing pesticides more carefully to better manage the target pest • On three years (2017, 2018 and 2020), surveys were sent to production nursery businesses that had submitted samples the previous year (about 300 clients). • This resulted in 39 respondents. Across the three years, similarly positive feedback was received: (a) About 90% of respondents indicated that recommendations were mostly or very relevant (b) About 70% of respondents indicated a moderate or greater reduction in pest/disease incidence as a result of implementing recommendations (c) About 85% indicated a moderate or greater improvement in crop health (d) About 60% indicated a moderate or greater reduction in management costs

	• This feedback indicated that most clients that submit samples to Grow Help benefit greatly after just one season of implementing recommendations. • Exercise Fastidious resulted in increased recognition of the value of using the Technical Feasibility of Eradication (TFE) tool to drive informed decision making, increased focus on surveillance, movement controls, and destruction, disposal and decontamination activities in detailed response strategies, and increased awareness of how Emergency Plan Pest Response Deed elements would be implemented. • The positive outcomes of NY150002 as contributed to additional funding for continuation of the work through a new project, NY20000 (Andrew Manners, pers. comm., 2022). • Also, over the life of the project (and predecessor projects), the nursery industry biosecurity project team experienced increased engagement with nursery businesses. For example, at the beginning of the initial project (NY11001) there were approximately 50 nursery samples per 60 months. Now the monitoring and surveillance team are receiving 170+ samples, and receiving samples more regularly, from all over the country and often receive feedback from growers indicating that they have very appreciated and benefitted from the assistance afforded by the projects (Andrew Manners, pers. comm., 2022). • The project investment has contributed to increased grower awareness, understanding, and utilisation of pest and disease monitoring, diagnostics, and other biosecurity services.
Potential Impacts	• Increased productivity and profitability for some production nursery enterprises because of improved on-farm pest and disease management practices. • Increased productivity and profitability for some production nursery enterprises through improved use of pest and disease monitoring, diagnostics, and technical advice from government agencies. • Increased cost of production for some nursery enterprises through adoption of new and improved pest and disease management practices (e.g. additional monitoring or hygiene practices). • Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases. • Reduced risk of the incursion and establishment of exotic pests and diseases through improved awareness and increased industry and government capacity to implement biosecurity plans and practices. • Some contribution to changes in chemical export off-farm through the use of pesticides. Some users may use less and/or more targeted pesticides, while some users may increase use of pesticides. Therefore, it is uncertain whether there would be a net positive or negative impact on the off-farm environment. • Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management.

Source: DAF project documentation and consultation with project personnel.

Nominal Investment

Table F2 shows the total annual investment made in Hort Innovation Project NY15002 by DAF and Hort Innovation. There were no other documented contributors to the RD&E project.

Table F2: Total Investment in Hort Innovation Project NY15002
(nominal dollar terms)

Year ended 30 June	DAF[(a)(b)] ($)	Hort Innovation ($)	Total ($)
2016	187,116	131,132	318,248
2017	371,582	260,407	631,989
2018	419,462	293,962	713,424
2019	437,864	306,858	744,722
2020	201,382	141,130	342,512
2021	397,217	278,373	675,590
Totals	**2,014,623**	**1,411,862**	**3,426,484**

Source: Project agreement and variations

(a) DAF investment costs included sub-contracts with PHA and NGIQ for $69,881.90 and $192,500.00 respectively.

(b) The allocation of DAF investment by financial year was derived based on the proportion of Hort Innovation investment in each financial year.

Management and Administration Costs

The Hort Innovation project agreement and variation budget data explicitly included overheads (including administration and project management) and additional DAF costs including corporate support, research facilities and infrastructure. Therefore, a management cost multiplier of 1.0 was applied to the DAF and Hort Innovation financial contributions shown in Table F2.

Real Investment and Extension Costs

For the purposes of the impact analysis, the investment costs of all parties were expressed in 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (Australian Bureau of Statistics (ABS), 2022).

Impacts

Table F3 provides a summary of the principal types of actual or potential impacts from Hort Innovation Project NY15002. Impacts have been taken and potentially expanded from those listed in Table F1 and categorised using a triple bottom line framework into economic, environmental, and social impact types.

Table F3: Principal Potential Impact Types from Investment in Hort Innovation Project NY15002

Economic	• Increased productivity and profitability for some production nursery enterprises because of improved on-farm pest and disease management practices. • Increased productivity and profitability for some production nursery enterprises through improved use of pest and disease monitoring, diagnostics, and technical advice from government or other agencies. • Increased cost of production for some nursery enterprises through adoption of new and improved pest and disease management practices (e.g. additional monitoring or hygiene practices). • Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases. • Reduced risk of the incursion and establishment of exotic pests and diseases through improved awareness and increased industry and government capacity to implement biosecurity plans and practices.
Environmental	• Some contribution to changes in chemical export off-farm through the use of pesticides. Some users may use less and/or more targeted pesticides, while some users may increase use of pesticides. Therefore, it is uncertain whether there would be a net positive or negative impact on the off-farm environment.
Social	• Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management.

Public versus Private Impacts

The investment in Hort Innovation Project NY15002 is likely to produce both public and private impacts. Private impacts will be delivered through increased productivity/profitability for some production nursery enterprises and a reduction in the risk of incursion and establishment of exotic pests. Public benefits are likely to be achieved through improved domestic and international perception of the Australian production nursery industry and, potentially, through improved environmental outcomes.

Distribution of Private Impacts

Private impacts will accrue initially to individual production nursery enterprises undertaking practice changes to improve pest and disease management. However, over the long-term benefits and costs are likely to be distributed along production nursery supply chains according to relevant supply and demand elasticities.

Impacts on Other Australian Industries

The nursery biosecurity capacity research has the potential to impact a range of nursery dependent industries such as urban horticulture, fruit and vegetable cropping, forestry, and the environment under land care and revegetation. Improved industry capacity to manage pest and disease risks in the production nursery industry may lead to positive impacts in related/dependent industries through reduced risk of the spread of pests and disease and, potentially, through reduced costs that flow through supply chains according to the supply and demand elasticities.

Impacts Overseas

No direct impacts to overseas parties were identified. However, some impacts on the nursery sector in other countries may occur through the sharing of scientific knowledge and international nursery stakeholder networks.

Match with National and State Priorities

The Australian Government's National Science and Research Priorities and Agricultural Innovation Priorities are reproduced in Table F4. The project included in the current analysis has contributed to National Science and Research Priority 1. The NY15002 investment also is likely to have contributed to Agricultural Innovation Priority 3, with some contribution to Priority 1.

Table F4: Australian R&D Priorities

Australian Government	
National Science and Research Priorities	**National Agricultural Innovation Priorities**
1. Food – optimising food and fibre production and processing; agricultural productivity and supply chains within Australia and global markets. **2. Soil and Water** – improving the use of soils and water resources, both terrestrial and marine. **3. Transport** – boosting Australian transportation: securing capability and capacity to move essential commodities; alternative fuels; lowering emissions. **4. Cybersecurity** – improving cybersecurity for individuals, businesses, government and national infrastructure. **5. Energy and Resources** – supporting the development of reliable, low cost, sustainable energy supplies and enhancing the long-term viability of Australia's resources industries. **6. Manufacturing** – supporting the development of high value and innovative manufacturing industries in Australia. **7. Environmental Change** – mitigating, managing or adapting to changes in the environment. **8. Health** – improving the health outcomes for all Australians. Source: 2015 Australian Government *Science and Research Priorities*. https://www.industry.gov.au/data-and-publications/science-and-research-priorities	On 11 October 2021, the National Agricultural Innovation Policy Statement was released. It highlights four long-term priorities for Australia's agricultural innovation system to address by 2030. These priorities replace the Australian Government's Rural Research, Development and Extension Priorities which were published in the 2015 Agricultural Competitiveness White Paper. **1.** Australia is a trusted exporter of premium food and agricultural products by 2030 **2.** Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 **3.** Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 **4.** Australia is a mature adopter, developer and exporter of digital agriculture by 2030 Source: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

The QLD Government's Agricultural RD&E Strategies, together with the four Investment Decision Rules that guide evaluation, prioritisation and decision making around QLD's future investment are reproduced in Table F5.

The investment addressed QLD Agriculture and Food RD&E Roadmap's Strategy 3 through support for improved management of pests and diseases and biosecurity risks. In terms of Investment Decision Rules, the investment is likely to have real future impact through improved productivity/profitability for the Australian production nursery industry, and through reduced risk of incursion and establishment of exotic pests. Also, the investment demonstrated external commitment through the active participation and co-investment by Plant Health Australia, Nursery and Garden QLD, and Hort Innovation through the nursery industry levy.

Table F5: QLD Government Research Priorities

QLD Government	
Agricultural RD&E Strategies	**Investment Decision Rule Guides**
1. Increase innovation and commercialisation **2.** Identify and promote agriculture and food RD&E opportunities **3.** Support existing sector to grow and develop new business Source: Queensland Agriculture and Food RD&E 10-year Roadmap and Action Plan 2018 https://www.publications.qld.gov.au/dataset/qld-agriculture-and-food-research-development-and-extension-roadmap/resource/5ab53e3a-b245-4271-aefc-774fcc560765	**1.** Real Future Impact **2.** External Commitment **3.** Distinctive Angle **4.** Scaling towards Critical Mass Source: Office of the Queensland Chief Scientist, https://www.chiefscientist.qld.gov.au/strategy-policies/decision-rules-for-investment

The QLD Government's current DAF Strategic Objectives are described in the DAF Strategic Plan 2021-2025 (Queensland Government, 2022). The current five objectives designed to guide DAF's investments and activities are:

1. **Innovative and globally competitive agribusinesses** accessing improved practices, data and new technologies to enhance the productivity, profitability and sustainability of food and fibre value chains.
2. **Prosperous economies** providing business and employment opportunities across regions, diversified markets, and value-added products and services.
3. **A resilient sector** with secure production and value chains that can deal with natural disasters, climate change, biosecurity risks and other emerging challenges.
4. **Ethical and sustainable production of food and fibre** that meets consumer and community expectations for food safety, a sage and sustainable natural environment and animal welfare and management standards.
5. **Trusted, capable and connected people** who are high-performing, safe, healthy and supported to deliver services and achieve their potential within the department and the community.

The investment in Project NY15002 has contributed to DAF Strategic Objective 3, with some contribution to Strategic Objective 5.

Valuation of Impacts

Impacts Valued

Three of the impacts identified in Table F3 were valued in the assessment. The three impacts were:

- Increased productivity and profitability for some production nursery enterprises because of improved on-farm pest and disease management practices.
- Increased productivity and profitability for some production nursery enterprises through improved use of pest and disease monitoring, diagnostics, and technical advice from government agencies.
- Increased cost of production for some nursery enterprises through adoption of new and improved pest and disease management practices (e.g. additional monitoring or hygiene practices).

The three impacts were valued using a single benefit valuation framework because of the difficulty disaggregating the benefits from improvements in on-farm management from the benefits from improved monitoring, diagnostics, and technical advice. Further, the benefit valuation framework was underpinned by the assumption that the investment in Hort Innovation Project NY15002 led to an increase in net profits, thus considering any additional costs of production incurred by producers adopting practice change.

Valuation of Impact 1: Increase in net profits for some Australian production nursery enterprises

The average annual gross value of production (GVP) for the nursery industry was estimated at $2.5 billion (Hort Innovation, 2021). It was assumed that net economic profit is approximately 10% of gross value and that a maximum of 15% of the total production nursery industry (as represented by total GVP) would achieve an increase in net profit of 0.5% as a result of adoption of practice changes attributable to the investment in Hort Innovation Project NY15002. Specific assumptions for the valuation of Impact 1 are described in Table F6 below.

Impacts Not Valued

Not all of the impacts identified in Table F3 could be valued within the scope of the assessment. In particular, environmental and social impacts typically are difficult to value and may require the application of complex and resource intensive non-market valuation techniques. Four impacts were not valued, these impacts were:

- Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases. This impact was not valued due to the difficulty in defining the pathways to impact and a lack of credible data on what industries may be impacted and how that impact would manifest.
- Reduced risk of the incursion and establishment of exotic pests and diseases through improved awareness and increased industry and government capacity to implement biosecurity plans and practices. This impact was not valued because of the uncertainty around what risk pathways for exotic pests and diseases may be impacted by any nursery industry practice change. Also, the type of pest and disease incursion and that change in risk were unknown.
- Some contribution to changes in chemical export off-farm through the use of pesticides. Some users may use less and/or more targeted pesticides, while some users may increase use of pesticides. This impact was not valued because it is uncertain whether there would be a net positive or negative impact on the off-farm environment, and there was a paucity of credible data on which to base necessary assumptions.
- Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management. This impact was not valued because of the complexity of placing monetary values on improved industry perception.

Summary of Assumptions

Table F6 describes the assumptions used in the valuation of impacts.

Table F6: Summary of Impact Valuation Assumptions

Variable	Assumption/Value	Source/Notes
Average annual GVP of the Australian production nursery industry	$2,548.1 million	Four-year average based on value of production data from the Hort Innovation Industry Statistics Handbook (2020 and 2021).
Proportion of industry (represented by total GVP) adopting practice change as a result of the investment	15%	Analyst assumption – based on the majority of nursery industry production being located across QLD, Victoria, and New South Wales and noting that the project had a QLD focus (led by DAF and including NGIQ).
Net profit (before tax) as a proportion of GVP **without** the investment in NY15002	10%	Analyst assumption – standard assumption for economic net profit when net profit data are unavailable.
Net profit (before tax) as a proportion of GVP **WITH** the investment in NY15002	10.5% (increase in net profit of 0.5%)	Analyst assumption – takes into consideration additional costs associated with adopting practice changes.
First year of impact	2021/22	Based on successful completion of project NY15002 in 2020/21.
Year of maximum impact	2025/26	Five years after the first year of impact to allow for adoption over time
Duration of maximum impact	5 years (from 2025/26 to 2029/30) Then declining to 50% of peak adoption levels by 2035/36	Analyst assumption – allows for some dis-adoption over time as well as the erosion of benefits due to external factors such as increased pest and disease pressure.
Other Factors		
Attribution of benefits to the investment in Hort Innovation Project NY15002	100%	Analyst assumption – conservative assumptions made to accommodate attribution to the investment.
Probability of output	100%	Based on successful completion of Hort Innovation Project NY15002 and stakeholder survey evidence of practice change/intention to change.
Probability of outcome	90%	Analyst assumption – takes into account that the level of adoption (15% of total nursery industry) and adoption profile assumed are somewhat uncertain.
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect the actual benefits realised (e.g. climate change, exotic pest incursion, etc.).
Counterfactual	It was assumed that, without the investment in Hort Innovation Project NY15002, the benefits estimated would not have occurred. This was supported by the fact that endemic pest and disease management typically is addressed predominantly by individuals at a farm level.	

Results

All benefit and cost cash flows were expressed in real 2021/22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022). All past and future benefit and cost cash flows were discounted to 2021/22 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of the investment (2020/21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Table F7 and F8 show the investment criteria estimated for different periods of benefits for the total investment in Hort Innovation Project NY15002and for the DAF investment respectively. The present value of benefits (PVB) for the DAF investment shown in Table F8 was estimated by multiplying the total PVB by the relative proportion of DAF investment in real, undiscounted dollar terms (66.6%).

Table F7: Investment Criteria for Total Investment in Hort Innovation Project NY15002

Investment Criteria	**Years from last year of investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	3.63	8.44	10.85	12.36	13.54	14.46
Present Value of Costs ($m)	3.57	3.57	3.57	3.57	3.57	3.57	3.57
Net Present Value ($m)	-3.57	0.06	4.87	7.29	8.79	9.97	10.89
Benefit-Cost Ratio	0.00	1.02	2.37	3.04	3.46	3.79	4.05
Internal Rate of Return (%)	n.s.	0.3	10.2	11.8	12.3	12.5	12.6
MIRR (%)	negative	5.2	10.8	10.7	10.1	9.6	9.2

n.s.: no unique solution

Table F8: Investment Criteria for DAF Investment in Hort Innovation Project NY15002

Investment Criteria	**Years from last year of investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.91	3.95	5.96	6.94	7.70	8.50
Present Value of Costs ($m)	1.88	2.10	2.10	2.10	2.10	2.10	2.10
Net Present Value ($m)	-1.88	-1.19	1.85	3.86	4.84	5.60	6.40
Benefit-Cost Ratio	0.00	0.43	1.88	2.84	3.31	3.67	4.05
Internal Rate of Return (%)	n.s.	0.3	10.2	11.8	12.3	12.5	12.6
MIRR (%)	negative	5.2	10.8	10.7	10.1	9.6	9.2

n.s.: no unique solution

The annual undiscounted benefit and cost cash flows for the total project investment for the duration of the investment plus 30 years from the last year of investment are shown in Figure F1 below.

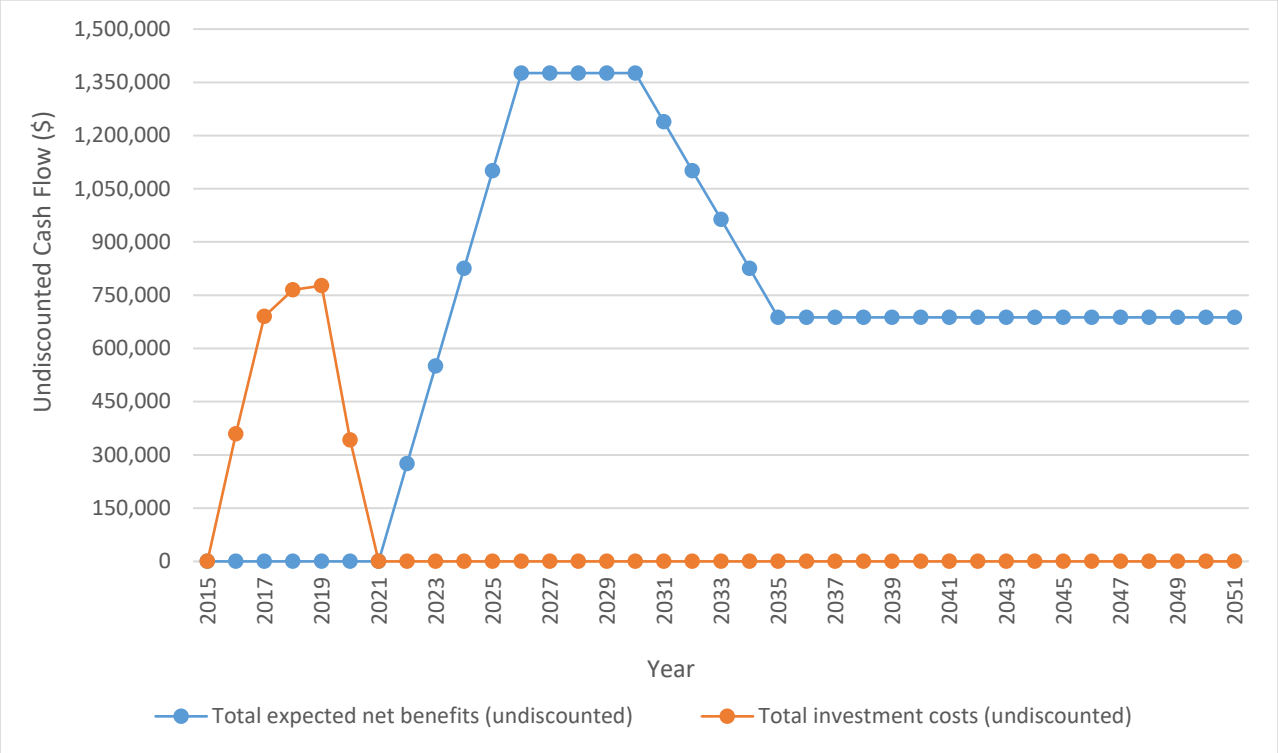

Figure F1: Annual Undiscounted Total Net Benefit and Total Investment Cost Cash Flows

Sensitivity Analyses

Sensitivity analyses were carried out on variables that were (a) considered key drivers of the investment criteria and/or (b) considered the most uncertain. The analyses were performed for the total proposed project investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

A sensitivity analysis was carried out on the discount rate. Table F9 presents the results that show a moderate sensitivity to the discount rate. This was largely because the benefit cash flows occur well into the future and were therefore subject to relatively more severe discounting.

Table F9: Sensitivity of Investment Criteria to the Discount Rate
(Total Investment, 30 Years)

Investment Criteria	**Discount Rate**		
	0.0%	**5.0% (Base)**	**10.0%**
Present Value of Benefits ($m)	25.46	14.46	9.51
Present Value of Costs ($m)	2.93	3.57	4.32
Net Present Value ($m)	22.52	10.89	5.20
Benefit-Cost Ratio	8.68	4.05	2.20

The assumption of the total proportion of the production nursery industry adopting practice change because of the project was a key driver of the investment criteria and was somewhat uncertain. A sensitivity analysis was carried out on the proportion of the nursery industry adopting changes. The results, presented in Table F10, show a moderate sensitivity to the assumed proportion of the nursery industry adopting change. A break-even analysis indicated that the investment criteria remain positive (that is, a benefit cost ratio of 1 to 1 or greater) even when the total proportion adopting drops to 3.7% of the total production nursery industry as represented by GVP (with all other parameters at base values).

Table F10: Sensitivity of Investment Criteria to the Total Proportion of the Production Nursery Industry Adopting Practice Change (Total Investment, 30 Years, 5% Discount Rate)

Investment Criteria	**Total Proportion of Production Nursery Industry Adopting Practice Change**		
	5% (Pessimistic)	**15% (Base)**	**25% (Optimistic)**
Present Value of Benefits ($m)	4.82	14.46	24.10
Present Value of Costs ($m)	3.57	3.57	3.57
Net Present Value ($m)	1.25	10.89	20.53
Benefit-Cost Ratio	1.35	4.05	6.75

A sensitivity analysis then was conducted on the assumed increase in net profits accruing to producers implementing practice changes. Table F11 shows the sensitivity results. The investment criteria showed a moderate to high sensitivity to the increase in net profits assumed. A break-even analysis showed that the investment criteria remained positive when the increase in net profits was as little as 0.12% (all other parameters held at base values).

Table F11: Sensitivity of Investment Criteria to the Increase in Net Profit (Total Investment, 30 Years, 5% Discount Rate)

Investment Criteria	**Number of Regional QLD Impoundments Adopting FAS**		
	0.1% (Pessimistic)	**0.5% (base)**	**1.0% (Optimistic)**
Present Value of Benefits ($m)	2.89	14.46	28.92
Present Value of Costs ($m)	3.57	3.57	3.57
Net Present Value ($m)	-0.68	10.89	25.35
Benefit-Cost Ratio	0.81	4.05	8.10

The sensitivity and break-even analyses suggest that, even when using relatively pessimistic assumptions for key variables, the investment criteria remain positive. This should give confidence to DAF, DAF RD&E funding partners, and industry stakeholders that the investment in Hort Innovation Project NY15002 has, and will, produce positive benefits for production nurseries and dependent industries.

Confidence Rating and Other Findings

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table F12). The rating categories used are High, Medium, and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table F12: Confidence in Analysis of Investment

Coverage of Benefits	Confidence in Assumptions
Medium	Low

Coverage of benefits was assessed as Medium. Three of seven impacts identified were valued in monetary terms using a single benefit valuation framework. The impacts valued were considered the most direct and important impacts of the investment. However, based on the assumptions made and the fact that several other impacts were identified but not valued, the investment criteria as presented are likely to be an underestimate of the true performance of the investment in Hort Innovation Project NY15002.

Confidence in assumptions for the impact valued was rated as Low. Many of the assumptions used in the valuation of impacts were underpinned by scientific literature, credible data, and/or expert opinion. However, there were no data to support assumptions regarding the level of adoption of practice change across the production nursery industry or level of productivity/profitability improvements assumed.

Discussion and Conclusions

The investment in Hort Innovation Project NY15002: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry* completed by DAF delivered a range of nursery industry biosecurity information, resources, training and education activities, and monitoring, diagnostics, and technical services to production nursery industry stakeholders.

The project activities and outputs were well received by participants with a significant proportion of those who engaged in training and education activities indicating intention to make positive practice changes as a result of the project. Further, the project has contributed to increased grower awareness, understanding, and utilisation of pest and disease monitoring, diagnostics, and other biosecurity services. This was evident through substantial increases in the amount and regularity of submission of suspect samples to the DAF nursery industry monitoring and surveillance team.

Through these outputs and outcomes, the investment in Hort Innovation Project NY15002 has led to a number of positive potential impacts for the production nursery and broader community. Potential impacts from the investment included:

- A net increased productivity and profitability for some production nursery enterprises because of:
  - Improved on-farm pest and disease management practices, and
  - Improved awareness and use of pest and disease monitoring, diagnostics, and technical advice from government agencies.
- Some contribution to increased productivity and profitability for other production nursery dependent industries through reduced incidence and spread of endemic pests and diseases.
- Contribution to improved domestic and international perception of the Australian production nursery industry because of increased adoption of best practice for endemic and exotic pest and disease management.

The total investment in Project NY15002 was estimated at $3.57 million (present value terms) and produced total expected net benefits of approximately $14.46 million (present value terms). This gave an estimated net present value of $10.89 million, a benefit-cost ratio of 4.1 to 1, an internal rate of return of 12.6% and a MIRR of 9.2% (over 30 years, using a 5% discount rate and 5% reinvestment rate for the MIRR).

Sensitivity and break-even analyses on key variables showed that the investment criteria remained positive even when relatively pessimistic assumptions were used. This should provide confidence that the investment has produced positive benefits for the production nursery industry and other nursery industry stakeholders.

Overall, the assessment of investment in Hort Innovation Project NY15002: *Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry* found that the project produced useful outputs that were well received by end-users and other stakeholders. Also, the project has, and is likely to, deliver positive impacts for Australian production nurseries and other dependent industries, as well as the broader Australian community. The investment should be viewed favourably by DAF, DAF funding partners, and nursery industry stakeholders.

References

Australian Government. (2015, May). Science and Research Priorities. *Science*. Department of Industry, Science, Energy and Resources. Retrieved from https://www.industry.gov.au/data-and-publications/science-and-research-priorities

Australian Government. (2022, January 13). *Agriculture, Forestry and Fishing: Regional Industry Data*. Retrieved from Australian Government - Labour Market Information Portal: https://lmip.gov.au/default.aspx?LMIP/GainInsights/IndustryInformation/AgricultureForestryandFishing

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved January 2022, from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Department of Agriculture, Water and the Environment. (2019, November 4). *Rural Research, Development and Extension Priorities*. Retrieved from Australian Government - Department of Agriculture, Water and the Environment: https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/priorities

Queensland Government. (2022, June 28). *Strategic Plan 2021-2025.* Retrieved from Queensland Government Department of Agriculture and Fisheries: https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c2beaba0-f97c-4e09-bff3-aade232a8eb8/20212025-strategic-plan-refreshed-for-2022department-of-agriculture-and-fisheries.pdf?ETag=7728e12854e445fac6df8b75f4522bdc