Benefit-Cost Analysis of the Drought and Climate Adaptation Program (DCAP0819)

AGGREGATE REPORT

[Final Report]

To

The Department of Agriculture and Fisheries Queensland

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Submitted by

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Acronyms & Abbreviations

ABDI	Agribusiness Development Institute
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BMP	Best Management Practice
BoM	Bureau of Meteorology
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
DCAP	Drought and Climate Adaptation Program
DES	Department of Environment and Sciences (Queensland)
GDP	Gross Domestic Product
IRR	Internal Rate of Return
M&E	Monitoring and Evaluation
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
RDC	Research and Development Corporation
RD&E	Research, Development and Extension
USQ	University of Southern Queensland

Glossary of Economic Terms

Benefit-Cost Analysis (BCA)	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) to Australia, regardless of to whom they accrue.
Investment criteria	Measures of the economic worth of an investment such as Net Present Value, Benefit Cost Ratio, and Internal Rate of Return.
Present Value of Costs (PVC)	The discounted value of RD&E investment costs.
Present Value of Benefits (PVB)	The discounted value of benefits.
Net Present Value (NPV)	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.
Benefit-Cost Ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to present value of costs.
Modified Internal Rate of Return (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are assumed re-invested at the rate of the cost of capital (a designated re-investment rate).

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Executive Summary

This report presents the results of a series of benefit-cost analyses (BCAs) of research, development and extension (RD&E) investments made by the Department of Agriculture and Fisheries, Queensland (DAF) in Phase 2 of the Drought and Climate Adaptation Program (DCAP). The DCAP Phase 2 Program is made up of a total of 10 project investments plus monitoring and evaluation (11 projects total) and spans the period 2017/18 to 2021/22. The projects are being delivered by DAF, the Department of Environment and Sciences (DES), the University of Southern Queensland (USQ), the Agribusiness Development Institute (ABDI), and consultant Jeff Coutts.

In 2020, the DCAP Phase 2 Program was at its mid-point and the Steering Committee overseeing delivery of the DCAP investments within the Queensland Drought Mitigation Centre required a comprehensive BCA to determine the economic, environmental and social impacts of the DCAP and to inform and refine future investment decisions. Agtrans Research, in association with AgEconPlus, was contracted to undertake the evaluation. Initial meetings between the evaluation team and DCAP management personnel led to agreement that the DCAP Phase 2 Program BCA would include nine of the DCAP Phase 2 investments.

Available documentation was assembled for each of the nine DCAP Phase 2 project investments with assistance from DCAP personnel and others involved with the investments and associated industries. Documentation included the original project proposals, project agreements, milestone reports, final reports where available, budget information for each investment (including variations), and other relevant reports.

Each of the nine analyses provides a description of the individual project including objectives, RD&E input costs (cash and in-kind), activities, outputs, outcomes, and potential and/or actual impacts. Impacts are first described qualitatively according to their contribution to the triple bottom line categories of economic, environmental and social impacts. Some of the identified impacts were then valued. The economic analyses were carried out using the current guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018). Impacts were estimated for 30 years from the year of last investment in each project.

Some identified impacts were not quantified, this was mainly due to:

- A suspected weak or uncertain scientific or causal relationship between the research investment and the actual RD&E outcomes and associated impacts.
- The magnitude of the value of the impact was considered to be only minor.
- A lack of credible data on which to base assumptions.

Total RD&E costs for each project included the investment in the project by DAF and other DCAP funding partners. The DAF contribution to the total investment made in each of the nine projects varied from 19.3% to 100.0% (real, undiscounted dollar terms). The RD&E costs for each project also demonstrate the significant leverage achieved by the DCAP Phase 2 investments. The leverage ratio (defined as the ratio of non-DAF investment to DAF investment in real, undiscounted dollar terms, including both cash and in-kind resources) ranged from 0.0 (project 100% funded by DAF) to approximately 4.2. The weighted average leverage ratio across all nine investments was approximately 2.0, that is, for every dollar that DAF invested, DCAP funding partners invested two dollars.

The tables below present the investment criteria for the total investment and the DAF investment in each of the nine investments respectively. Eight of the nine projects had impacts that were valued in monetary terms. The investments were evaluated using a 5%

discount rate, with benefits valued over 30 years from the last year of investment. All costs and benefits were expressed in 2019/20 dollar terms and discounted to 2019/20 (the year of analysis).

Investment Criteria for Total Investment by Project

Investment	PVB ($m)	PVC ($m)	NPV ($m)	BCR	IRR (%)	MIRR (%)
DES1	46.27	8.08	38.19	5.73	24.91	11.21
DES2	NR	1.46	NR	NR	NR	NR
DES3	4.40	0.75	3.66	5.91	24.67	10.81
USQ4	83.66	15.91	67.74	5.26	23.79	12.32
USQ5	10.53	2.62	7.91	4.02	19.95	9.38
DAF6	6.22	1.36	4.85	4.57	20.13	7.62
DAF7	4.53	0.98	3.55	4.64	30.09	9.85
DAF8	27.88	6.05	21.83	4.61	21.36	7.98
DAF9	24.80	3.26	21.54	7.61	31.21	12.15

NR: Not Reported

Investment Criteria for DAF Investment by Project

Investment	PVB ($m)	PVC ($m)	NPV ($m)	BCR	IRR (%)	MIRR (%)
DES1	14.24	2.52	11.72	5.65	23.93	10.20
DES2	NR	0.42	NR	NR	NR	NR
DES3	1.95	0.33	1.62	5.92	24.84	10.82
USQ4	16.18	3.02	13.16	5.35	25.22	11.29
USQ5	4.53	1.13	3.40	4.02	19.95	9.38
DAF6	1.53	0.33	1.20	4.62	20.70	7.79
DAF7	4.53	0.98	3.55	4.64	30.09	9.85
DAF8	19.24	4.18	15.06	4.60	21.31	7.98
DAF9	5.79	0.76	5.02	7.59	30.83	12.13

NR: Not Reported

Benefit and cost cash flows from the nine individual project analyses then were aggregated to produce investment criteria for the DCAP Phase 2 Program as a whole. Eight of the nine DCAP Phase 2 project investments had impacts that were valued in monetary terms. Two analyses were carried out at a DCAP Phase 2 Program level. In the first analysis, the PVB for the eight projects valued was compared to the total investment in all nine projects that formed the DCAP Phase 2 Program evaluation. As there are likely to be positive impacts from the project where impacts were not explicitly valued, the results from this analysis are likely to represent a lower bound set of investment criteria for the DCAP Phase 2 Program.

The table below shows the ‘lower bound’ investment criteria estimated for the different periods of benefits for the total investment in the nine DCAP Phase 2 projects.

Lower Bound Investment Criteria for Total Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	7.29	57.83	109.92	145.71	172.08	192.74	207.17
PVC ($m)	40.46	40.46	40.46	40.46	40.46	40.46	40.46
NPV ($m)	-33.16	17.37	69.47	105.25	131.62	152.28	166.71
BCR	0.18	1.43	2.72	3.60	4.25	4.76	5.12
IRR (%)	negative	12.63	21.10	22.75	23.20	23.35	23.40
MIRR (%)	negative	10.38	13.32	11.80	10.34	9.20	8.23

The second analysis refers to the same set of valued benefits (estimated total PVB of $207.17 million at a 5% discount rate, 30 years from the last year of investment) but compared them to the specific investment costs of only the eight projects contributing to the benefits valued. This second analysis is likely to estimate an upper bound set of investment criteria for the DCAP Phase 2 Program investment.

The table below shows the ‘upper bound’ investment criteria estimated for the different periods of benefits for the total investment.

Upper Bound Investment Criteria for Total Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	7.29	57.83	109.92	145.71	172.08	192.74	207.17
PVC ($m)	39.00	39.00	39.00	39.00	39.00	39.00	39.00
NPV ($m)	-31.71	18.82	70.92	106.71	133.08	153.74	168.17
BCR	0.19	1.48	2.82	3.74	4.41	4.94	5.31
IRR (%)	negative	13.45	21.77	23.36	23.80	23.93	23.98
MIRR (%)	negative	11.04	13.72	12.08	10.55	9.37	8.37

Assuming that some benefits existed in the project not valued in monetary terms, the BCR for the total investment in all nine projects is likely to lie somewhere between 5.1 and 5.3 to 1.

Based on the conservative assumptions made in the individual DCAP Phase 2 project evaluations (Appendices A to I), the restriction of the valuation of some benefits to QLD and the beef industry only, and the fact that a number of impacts identified were not valued in monetary terms, the aggregate investment criteria reported are likely to be an underestimate of the true performance of the DCAP Phase 2 Program investment. The analysis indicates that the DCAP Phase 2 Program has delivered, and will continue to deliver, positive impacts to QLD, and Australian, primary industries, Government and the wider community. The results should be viewed positively by DCAP Management, DAF, Australian primary industries and other DCAP funding partners, as well as policy personnel responsible for allocation of public funds.

1. Introduction

This report presents the results of a series of benefit-cost analyses (BCAs) of research, development and extension (RD&E) investments made by the Department of Agriculture and Fisheries, Queensland (DAF) in Phase 2 of the Drought and Climate Adaptation Program (DCAP). The DCAP Phase 2 Program is made up of a total of 10 project investments plus monitoring and evaluation (M&E) (11 projects in total) and spans the period 2017/18 to 2021/22. The projects are being delivered by DAF, the Department of Environment and Sciences (DES), the University of Southern Queensland (USQ), the Agribusiness Development Institute (ABDI), and consultant Jeff Coutts and include:

- DES1: The inside edge for graziers to master QLD's drought prone climate: information systems to manage drought more effectively (4 year project);
- DES2: Do we really known our baseline climate? Using paleo-climate data to plan and prepare for extreme events and floods in QLD (4 year project);
- DES3: Enabling drought resilience and adaptation: a program of social research and knowledge support (4 year project);
- USQ4: Northern Australia climate program (4 year project);
- USQ5: Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2 (4 year project);
- DAF6: Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing systems (3 year project);
- DAF7: Use of BoM's multi-week and seasonal forecasts to facilitate improved management decisions in QLD's vegetable industry (4 year project);
- DAF8: Grazing Futures: promoting a reliant grazing industry. Supporting western QLD grazing businesses to prosper and grow based on BMPs, science and industry experience (4 year project);
- DAF9: Forewarned is forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events (5 year project);
- ABDI10: Business mentoring for the grazing industry; and
- COUTTSJR11: DCAP monitoring and evaluation.

In 2020, the DCAP Phase 2 Program was at its mid-point and the Steering Committee overseeing delivery of the DCAP investments within the Queensland Drought Mitigation Centre required a comprehensive BCA to determine the economic, environmental and social impacts of the DCAP and to inform and refine future investment decisions. Agtrans Research, in association with AgEconPlus, was contracted to undertake the evaluation. Initial meetings between the evaluation team and DCAP management personnel led to agreement that the BCA would include nine of the DCAP Phase 2 investments (DES1 through to DAF9). ABDI10 was excluded from the analysis as it was considered a separate capacity building project, with only minor DAF investment, that was being managed externally. Further, the evaluation team was to collaborate with the M&E team to potentially improve both BCA and future M&E outcomes for the DCAP Program.

A summary of methods used in the analysis is provided in Section 2, including the steps involved in the evaluation of each of the nine individual investments. Section 3 summarises the impacts identified for the DCAP Phase 2 investment evaluation. Section 4 reports the investment criteria for each of the investments evaluated as well as investment criteria for the aggregate investment. A brief conclusion is provided in Section 5. Appendices A to I provide the detailed impact assessments and analyses for each of the nine investments.

2. Methods

The evaluation approach used in the analysis followed guidelines that are now well accepted within the Australian primary industry research sector including Rural Research and Development Corporations (RDCs), Cooperative Research Centres and some universities. The evaluation includes both qualitative and quantitative approaches with the latter using BCA as a primary tool. The evaluation was conducted in accord with the current guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

Each of the nine DCAP Phase 2 investments was evaluated through the following steps:

- Information from any original project documentation, including proposals and schedules, progress reports, and other relevant reports, was assembled with assistance from DCAP/DAF personnel.
- An initial description of the relevant background, objectives, RD&E costs, activities, outputs, and expected outcomes and impacts was drafted for each of the nine investments. Additional information needs were then identified.
- The actual and/or potential impacts from each investment were identified and described in a triple bottom line context. Some of these impacts were then valued as part of the BCA.
- Telephone and/or email contact was made with relevant project personnel (i.e. Principal Investigators) and the initial draft project description sent to them for perusal and comment, together with specific information requests.
- Further information and data were assembled where appropriate from publications and consultation with other project stakeholders (e.g. industry participants/stakeholders and/or other researchers).
- Some analyses proceeded through several drafts, both internally within the evaluation team as well as externally via DCAP Project Leaders and other reviewers.
- Draft reports for each investment were provided to DCAP management for comment.
- Comments on each of the draft reports were addressed and incorporated into a final report that was provided to DCAP management (see appendices A to I).

In general, the factors that drive the investment criteria for RD&E include:

- The cost of the RD&E.
- The magnitude of the net benefit per unit of production affected; this net benefit per unit also takes into account any additional costs of implementation/usage.
- The quantity of production affected by the RD&E, in turn a function of the size of the target audience and/or applicable area, and the level of initial and maximum adoption ultimately expected, the expected commencement year of adoption and the level of adoption in the intervening years.
- The discount rate.
- An attribution factor that can apply when the specific project or investment being considered is only one of several pieces of research or activity that have contributed to the impact being valued.
- The assumptions associated with the ‘without RD&E’ scenario, referred to as the ‘counterfactual’.

Following qualitative assessment of the nine DCAP Phase 2 investments, BCAs were conducted individually on eight of the nine projects. The Present Value of Benefits (PVB) and Present Value of Investment Costs (PVC) were used to estimate investment criteria for each of the eight projects including the Net Present Value (NPV) and Benefit-Cost Ratio (BCR) at a discount rate of 5%. The Internal Rate of Return (IRR) was estimated from the annual net cash flows. The Modified Internal Rate of Return (MIRR) for each investment also was estimated. The MIRR is a modified IRR estimated so that any positive cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate). For these analyses, the re-investment rate was set at 5% as required by the CRRDC. These terms are defined in the Glossary of Economic Terms at the beginning of this report. Impacts identified for Project DES2 were not able to be valued in monetary terms within the scope of the current evaluation, specific reasons for this are outlined in the relevant project evaluation (Appendix B). Thus, for DES2, only the PVC was estimated and reported.

All costs and benefits were expressed in 2019/20 real dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) and discounted to 2019/20 (year of analysis). A 30-year benefit time frame was used in all analyses, with benefits estimated for up to 30 years from the year of last investment in each project. Total investment costs for each project included the expenditure on the project by DAF and the major DCAP funding partners, as well as any other resources, including in-kind resources, contributed by third parties. Investment criteria were estimated and reported for the total investment as well as for the investment by DAF alone. A degree of conservatism was used when making specific assumptions. Sensitivity analyses were undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.

Some identified impacts were not quantified mainly due to factors such as:

- A suspected weak or uncertain scientific or causal relationship between the research investment and the associated outputs, outcomes and impacts.
- The magnitude of the value of the impact was thought to be only minor.
- A lack of data on which to base credible assumptions for valuation.

Once each of the individual analyses was finalised, the undiscounted cash flows (benefits and costs) from each of the nine BCAs were combined to provide the basis for the estimation of aggregate investment criteria for the DCAP Phase 2 Program. Aggregate investment criteria were generated for the total investment and for the DAF investment separately, across all nine investments combined.

3. Summary of Impacts

As part of the evaluation process, the individual impacts identified and described for each of the nine DCAP Phase 2 projects were summarised and then categorised into economic, environmental and social impact types. Table 1 shows the specific impacts identified for each of the DCAP project investments.

Table 1: DCAP Phase 2 Project Impacts

DCAP Phase 2 Project	**Industries Targeted**	**Impacts Identified**
DES1: *Inside Edge for graziers to master Queensland's drought-prone climate.*	Grazing, Sorghum	• Increased annual average productivity and profitability of some QLD graziers through improved management decisions. • Reduced variability of annual net income by some QLD graziers • The productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. • Improved land condition and sustainability including decreased soil loss of some pastoral properties and reduced soil runoff to external environments. • Potential for a reduction in costs of drought support by Queensland government to QLD graziers. • Maintenance of social licence for grazing activities in pastoral Queensland. • Spillovers to regional communities from increased and less variable incomes for QLD livestock producers and their associated supply chain businesses. • Reduced stress experienced by pastoral system managers. • Maintained/increased QLD applied modelling capability and capacity associated with grazing management, and ensuring capacity is current through increasing testing and use of remotely-sensed data, backed up by field-collected data.
DES2: *Do we really know our baseline climate? Using palaeoclimatic data to better plan and prepare for extreme droughts and floods in Queensland.*	Public water agencies and irrigators	• The range of impacts delivered by the outcomes above will depend on the framework for decision makers who benefit, and the specific decisions that the new data are expected to influence. Specific impacts could include: • Reduced net economic and social losses from extreme climatic events due to improved capital investment planning and operational management for Seqwater water sources and associated risk management planning by irrigators.

		• Potential for reduced vegetation, soil, and wildlife loss and damage due to improved planning for extreme climate events. • Reduced personal and community trauma and improved wellbeing. • Increased scientific capability and capacity.
DES3: *Enabling drought resilience and adaptation: A program of social research and knowledge support.*	Grazing	• Increased productivity and profitability benefits for QLD grazing enterprises (increased net farm income for QLD beef producers); • Contribution to reduced cost to QLD government for drought support; • Decreased damage to land and water resources as a result of more informed drought management decisions. Less environmental damage will help maintain the QLD grazing industry's social licence to operate; • Improved drought management and response skills developed by graziers; • Enhanced drought policy insights developed by researchers and government policy makers; • Increased scientific knowledge and research capacity; and • Contribution to improved regional community wellbeing from spill-over benefits from more productive and profitable grazing enterprises.
USQ4: *Innovative drought and climate variability RD&E to enhance business resilience and build producer capacity to manage climate risk across the northern Australian red meat industry.*	Grazing (northern red meat)	• Increased average annual productivity and profitability for some Northern Australia pastoral managers from three sources: o new users of seasonal climate forecasting aids. o an increase in the value of seasonal forecasting impacts for those decision makers who already use climate forecasting. o decisions by producers before and during a drought made with greater certainty due to the improved multi-year forecasts. • Any productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. • Reduced variability of annual net income for some Northern Australia red meat producers from improved management decision making (e.g. destocking, restocking) that takes into account seasonal and multi-year climate forecasts. • Improved government policy development regarding drought assistance. • Improved environmental management for some Northern Australia red meat producers. • Increased scientific and extension capability and capacity. • Reduced personal and community trauma and improved wellbeing. • Maintained social licence for grazing activities in Northern pastoral areas.

		• Impacts of improved climate forecasts to a wider set of businesses and individuals in Northern Australia outside of the red meat industry.
USQ5: *Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2.*	Sugarcane, Cotton	• Increased long-term profitability for sugarcane growers adopting the project generated DMF for cyclone risk. A DMF for sugarcane cyclone risk was the most well developed product originating from USQ5. • Reduced income variability and increased investment confidence for sugarcane growers adopting the project generated DMF for cyclone risk. • Longer term potential for improved profitability and reduced income variability for other primary producers adopting potential USQ5 products – i.e. growers of cotton, macadamia, sweet corn, lettuce and wheat. • Contribution to reduced cost to QLD government for disaster recovery assistance. • Improved development of government policy with additional climate risk insight. • Additional understanding of weather and climatic risk, financial risk management using insurance by researchers and primary producers • The training of a PhD student in agricultural risk management / financial instruments. • Potential positive mental health impacts for individual farmers, possibly even suicide prevention. • Contribution to improved regional community wellbeing from spill-over benefits from a more profitable and stable Australian crop sector.
DAF6: *Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises.*	Grazing (beef and sheep)	• Increased average, annual productivity and profitability for some graziers (particularly beef and sheep grazing enterprises in QLD) through improved management decisions to prepare for, respond to, or recover from, drought and future climate variability. • Reduced variability of net farm incomes through improved farm management and decision making. • Improved soil condition for some pastural properties driven by decreased soil erosion and increase soil condition leading to improved water and nutrient retention (reduced run-off to external environments), and enhanced biodiversity. • Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

DAF7: *The Use of Bureau of Meteorology (BoM) Multi-Week and Seasonal Forecasts to Facilitate Improved Management Decisions in Queensland's Vegetable Industry.*	Lettuce, Broccoli and Sweetcorn	• Reduction in vegetable (lettuce, broccoli, sweet corn) income loss caused by extreme heat and rainfall events. • More reliable supply of fresh vegetables for packer/marketers. • Improved crop management with decreased loss of soil to waterways and an improvement in the vegetable industry's social licence to operate. • Vegetable growers with new skills in climate forecasting and in responding to forecast climate information. • DAF researchers with new skills in climate forecasting and management responses. • Contribution to improved regional community wellbeing from spill-over benefits from more profitable/less variable vegetable production.
DAF8: *Building Drought Resilience (GrazingFutures).*	Grazing	• Increased average, annual productivity and profitability for some graziers in western QLD through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience. • Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).
DAF9: *Forewarned is Forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events.*	Sugarcane, northern red meat	• Increased sugar and northern red meat producer average annual profitability and/or reduced income variability. • Positive impacts on the profitability of other agricultural industries (e.g. horticulture) and sectors of the Australian economy (e.g. building industry, disaster management). • Additional protection for the grazing resource and the natural environment with, for example, earlier destocking decisions, resulting in an enhanced social licence to operate. • Sugar and northern red meat producers with new skills in climate forecasting and in responding to forecast climate information. • USQ and DAF researchers with new skills in climate forecasting and management response. • Contribution to improved regional community wellbeing from spill-over benefits from more profitable/less variable sugar and red meat production.

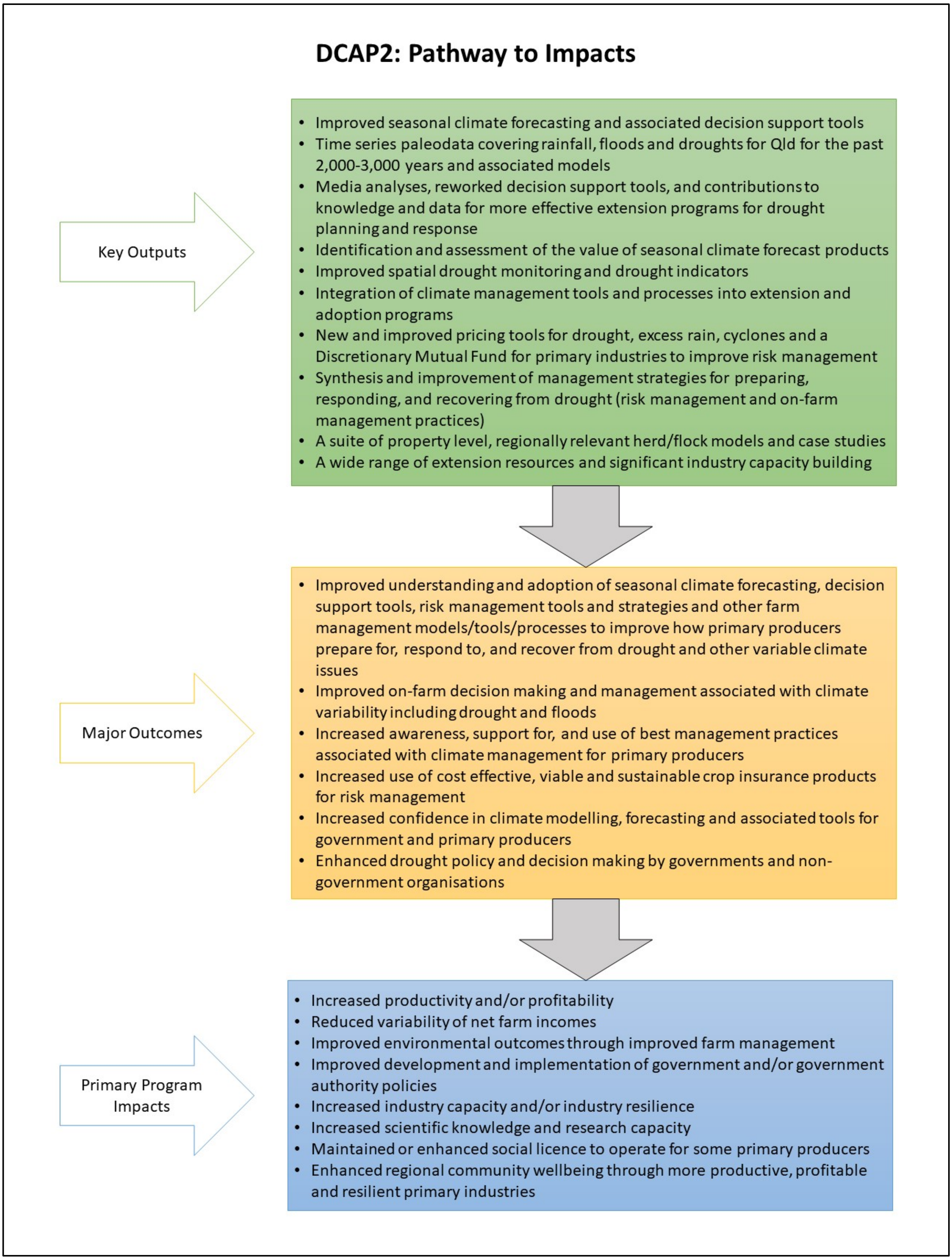
Table 2: Categorisation of DCAP Phase 2 Project Impacts by Triple Bottom Line Impact Type

Project	Impact Type							
	Increased productivity/ profitability[(a)]	Reduced variability of net farm income	Improved environmental outcomes[(b)]	Improved development and implementation of govt./ govt. authority policies	Increased industry capacity/ improved industry resilience	Increased scientific knowledge and/ or research capacity	Maintained or enhanced social licence to operate	Increased regional community wellbeing[(c)]
DES1	✓	✓	✓	✓	✓	✓	✓	✓
DES2	✓		✓		✓	✓		✓
DES3	✓	✓	✓	✓	✓	✓	✓	✓
USQ4	✓	✓	✓	✓	✓	✓	✓	✓
USQ5	✓	✓		✓	✓	✓	✓	✓
DAF6	✓	✓	✓		✓		✓	✓
DAF7	✓	✓	✓		✓	✓	✓	✓
DAF8	✓	✓	✓		✓		✓	✓
DAF9	✓	✓	✓		✓	✓	✓	✓

(a) Driven by improved decision making (for existing users and from increased adoption of decision-making tools/ resources), reduced economic/ income losses, lower intervention costs for landholders and/ or government, and less variable supply.
(b) Including: reduced erosion, improved soil condition, reduced wildlife and/ or vegetation loss, and decreased damage to land and/ or water resources.
(c) Includes spill-over benefits from increased industry productivity/ profitability impacts.

Figure 1 summarises the principle pathway to impacts for the DCAP Phase 2 investment. Further detail on the key outputs and outcomes of the Program can be found in the individual project analyses (Appendices 1 to 9).

Figure 1: Summary of the Pathway to Impacts for Investment in DCAP2



4. Summary of Results

4.1 Individual Project Results

For each project, investment criteria were estimated for both the total investment and the DAF investment alone and summarised in Table 3 (Total) and Table 4 (DAF) for each of the nine investments analysed at a 5% discount rate. The impacts for DES2 were not valued in monetary terms so only the PVC was reported. Further details on each of the investments analysed and the associated results are provided in the individual evaluation reports presented in the Appendix (Appendices A to I).

Table 3: Investment Criteria for Total Investment by Project
(discount rate 5%, 30 years from last year of investment)

Investment	PVB ($m)	PVC ($m)	NPV ($m)	BCR	IRR (%)	MIRR (%)
DES1	46.27	8.08	38.19	5.73	24.91	11.21
DES2	NR	1.46	NR	NR	NR	NR
DES3	4.40	0.75	3.66	5.91	24.67	10.81
USQ4	83.66	15.91	67.74	5.26	23.79	12.32
USQ5	10.53	2.62	7.91	4.02	19.95	9.38
DAF6	6.22	1.36	4.85	4.57	20.13	7.62
DAF7	4.53	0.98	3.55	4.64	30.09	9.85
DAF8	27.88	6.05	21.83	4.61	21.36	7.98
DAF9	24.80	3.26	21.54	7.61	31.21	12.15

NR: Not Reported

Table 4: Investment Criteria for the DAF Investment by Project
(discount rate 5%, 30 years from last year of investment)

Investment	PVB ($m)	PVC ($m)	NPV ($m)	BCR	IRR (%)	MIRR (%)
DES1	14.24	2.52	11.72	5.65	23.93	10.20
DES2	NR	0.42	NR	NR	NR	NR
DES3	1.95	0.33	1.62	5.92	24.84	10.82
USQ4	16.18	3.02	13.16	5.35	25.22	11.29
USQ5	4.53	1.13	3.40	4.02	19.95	9.38
DAF6	1.53	0.33	1.20	4.62	20.70	7.79
DAF7	4.53	0.98	3.55	4.64	30.09	9.85
DAF8	19.24	4.18	15.06	4.60	21.31	7.98
DAF9	5.79	0.76	5.02	7.59	30.83	12.13

NR: Not Reported

The PVCs in Table 4 (DAF investment only) compared to those in Table 3 (Total investment) demonstrate the importance of DAF funding in all of the nine DCAP Phase 2 investments. As a proportion of total funding in each of the nine investments, DAF funding varied from approximately 19.3% (USQ4) to 100.0% (DAF7) with a weighted average of 33.7% across all nine investments (real, undiscounted dollar terms).

Further, these results demonstrate the significant leverage achieved by the DCAP Phase 2 investments. The leverage ratio (defined as the ratio of non-DAF investment to DAF investment in real, undiscounted dollar terms, including both cash and in-kind resources) ranged from 0.0 for project DAF7 (which was 100% funded by DAF) to approximately 4.2 for USQ4. The weighted average leverage ratio across all nine investments was approximately 2.0, that is, for every dollar that DAF invested, DCAP funding partners invested two dollars.

4.2 Aggregate Results

Benefit and cost cash flows from the nine individual project analyses were aggregated to produce investment criteria for the DCAP Phase 2 Program as a whole. Eight of the nine DCAP Phase 2 project investments had impacts that were valued in monetary terms.

Two analyses were carried out at a DCAP Phase 2 Program level. In the first analysis, the PVB for the eight projects valued was compared to the total investment in all nine projects that formed the DCAP Phase 2 Program evaluation. As there are likely to be positive impacts from the project where impacts were not explicitly valued, the results from this analysis are likely to represent a lower bound set of investment criteria for the DCAP Phase 2 Program. Table 5 and Table 6 show the ‘lower bound’ investment criteria estimated for the different periods of benefits for the total investment and for the DAF investment respectively.

Table 5: Lower Bound Investment Criteria for Total Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	7.29	57.83	109.92	145.71	172.08	192.74	207.17
PVC ($m)	40.46	40.46	40.46	40.46	40.46	40.46	40.46
NPV ($m)	-33.16	17.37	69.47	105.25	131.62	152.28	166.71
BCR	0.18	1.43	2.72	3.60	4.25	4.76	5.12
IRR (%)	negative	12.63	21.10	22.75	23.20	23.35	23.40
MIRR (%)	negative	10.38	13.32	11.80	10.34	9.20	8.23

Table 6: Lower Bound Investment Criteria for the DAF Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	2.40	19.54	37.83	49.03	57.09	63.40	67.77
PVC ($m)	13.67	13.67	13.67	13.67	13.67	13.67	13.67
NPV ($m)	-11.27	5.87	24.17	35.37	43.42	49.73	54.11
BCR	0.18	1.43	2.77	3.59	4.18	4.64	4.96
IRR (%)	negative	12.52	21.16	22.66	23.07	23.21	23.25
MIRR (%)	negative	10.29	13.38	11.63	10.10	8.95	7.99

The second analysis refers to the same set of valued benefits (estimated total PVB of $207.2 million at a 5% discount rate, 30 years from the last year of investment) but compared them to the specific investment costs of only the eight projects contributing to the benefits valued. This second analysis is likely to estimate an upper bound set of investment criteria for the DCAP Phase 2 Program investment.

Table 7 and Table 8 show the 'upper bound' investment criteria estimated for the different periods of benefits for the total investment and for the DAF investment respectively.

Table 7: Upper Bound Investment Criteria for Total Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	7.29	57.83	109.92	145.71	172.08	192.74	207.17
PVC ($m)	39.00	39.00	39.00	39.00	39.00	39.00	39.00
NPV ($m)	-31.71	18.82	70.92	106.71	133.08	153.74	168.17
BCR	0.19	1.48	2.82	3.74	4.41	4.94	5.31
IRR (%)	negative	13.45	21.77	23.36	23.80	23.93	23.98
MIRR (%)	negative	11.04	13.72	12.08	10.55	9.37	8.37

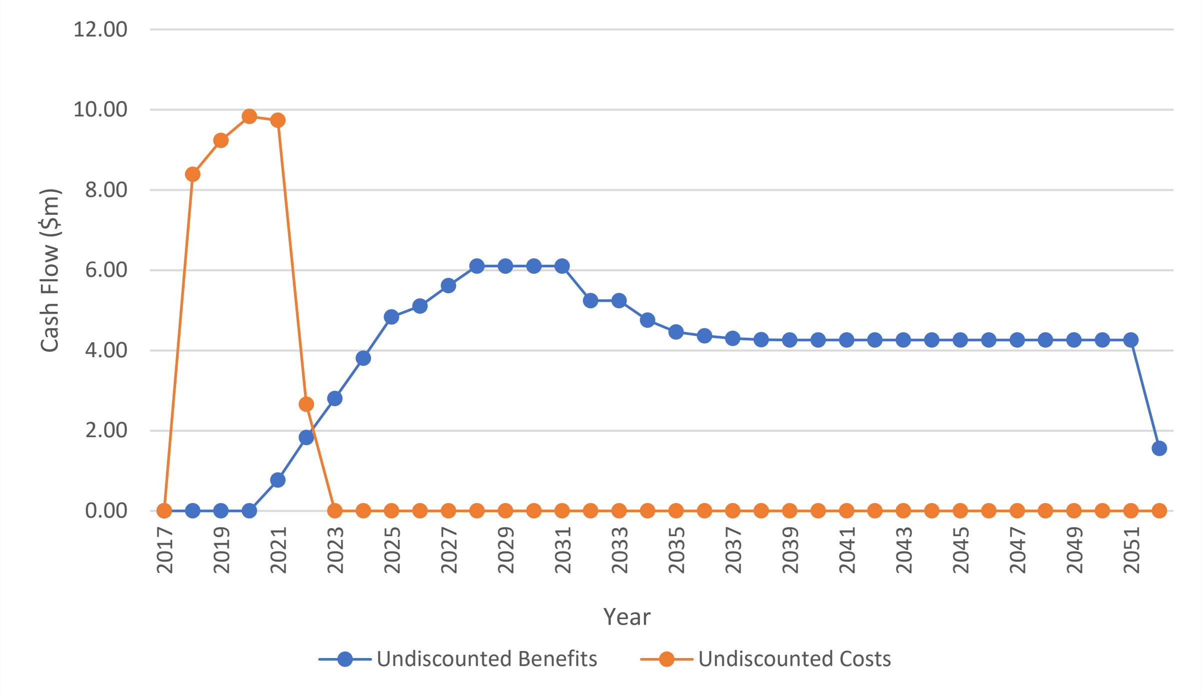
Table 8: Upper Bound Investment Criteria for the DAF Investment in the Nine DCAP Phase 2 Program Investments (Discount rate 5%)

Investment Criteria	**Years from last year of aggregate investment (2021/22)**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
PVB ($m)	2.40	19.54	37.83	49.03	57.09	63.40	67.77
PVC ($m)	13.25	13.25	13.25	13.25	13.25	13.25	13.25
NPV ($m)	-10.85	6.29	24.59	35.78	43.84	50.15	54.53
BCR	0.18	1.47	2.86	3.70	4.31	4.79	5.12
IRR (%)	negative	13.22	21.74	23.21	23.60	23.73	23.77
MIRR (%)	negative	10.84	13.71	11.85	10.27	9.09	8.11

The upper bound investment criteria (e.g. BCR of 5.31) for the total investment were only slightly higher than the lower bound investment criteria (e.g. BCR of 5.12, total investment). This was because only one project of the nine DCAP Phase 2 investments had impacts that were not valued in monetary terms and this project, DES2, represented only 3.6% of the total PVC. Thus, the difference between the upper and lower bound investment criteria is driven by only the investment costs of the DES2 project that did not directly contribute to the PVB. Assuming that some benefits existed in the project not valued in monetary terms, the BCR for the total investment in all nine projects is likely to lie somewhere between 5.1 and 5.3 to 1.

Figure 1 illustrates the undiscounted cash flows for the estimated total benefits from the eight projects valued and the total RD&E investment costs for all nine projects evaluated for the DCAP Phase 2 Program.

Figure 2: Annual Undiscounted Cash Flows for Estimated Total Expected Benefits and Total RD&E Investment Costs for Nine Projects in the DCAP Phase 2 Program



The drop in the total undiscounted expected benefits in 2052 is because, for the individual project BCAs, benefits and costs were estimated for a period of 30 years from the last year of investment and seven of the nine DCAP Phase 2 projects recorded a final year of investment as 2020/21. Thus, only the estimated benefits from two projects, USQ4 and DAF9 with a final year of investment of 2021/22, continue through to 2051/52.

Table 9 shows the contribution of the estimated benefits for each of the nine DCAP Phase 2 projects to the total PVB.

Table 9: Contribution of Individual Projects to the Total PVB

DCAP Phase 2 Project	**Project PVB ($m)**	**Contribution of Project PVB to Aggregate Total PVB (%)**
DES1	46.27	22.4
DES2	0.00	0.0
DES3	4.40	2.1
USQ4	82.39	39.8
USQ5	10.53	5.1
DAF6	6.22	3.0
DAF7	4.53	2.2
DAF8	27.88	13.5
DAF9	24.95	12.0
Total	207.17	100.0

4.3 Sensitivity Analyses

Sensitivity analyses were undertaken for the total investment with benefits taken over the life of the DCAP Phase 2 investment plus 30 years from the last year of investment (2021/22). All other variables were kept constant at base values. In general, the sensitivity analyses indicate how the results change with changes to the underlying BCA assumptions tested. A high sensitivity would indicate that the assumption variable has a significant influence on the estimated aggregate investment criteria.

A sensitivity analysis was carried out on the discount rate as shown in Table 10. This analysis refers to the eight projects where benefits were valued (total benefits) and includes the investment costs for all nine projects (lower bound). The results showed a moderate sensitivity to the discount rate. The impact of the discount rate is largely due to the significant proportion of benefit cash flows that occur well into the future and are therefore more heavily influenced by discounting.

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

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
PVB ($m)	432.73	207.17	118.07
PVC ($m)	39.85	40.46	41.19
NPV ($m)	392.89	166.71	76.89
BCR	10.86	5.12	2.87

Next, sensitivity analyses were conducted on several key assumptions for benefits where a number of projects contributed to the impact valued. A range of impacts were valued in the individual project analyses (Appendices A to I). Of these impacts there were two key impacts where a large number of the DCAP Phase 2 projects contributed to the estimated benefits. These impacts were:

- Increased average, annual productivity and profitability for some graziers in QLD (estimated through an increase in average annual net farm incomes), and
- Maintained or enhanced social licence to operate for some QLD grazing enterprises (estimated through a reduced risk of loss of profits).

The two impacts identified above were valued at a DCAP Program level. Six of the nine DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to the two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

- Though some benefits from the six contributing projects would accrue to graziers in the Northern Territory and the north of Western Australia, the main emphasis of the DCAP projects was in QLD,
- The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising approximately 50% of the national heard of 22.4 million head (ABS, 2020). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and

- The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

For further detail about the specific valuations and the assumptions used, please refer to the relevant individual project evaluations (Appendices A, C, D, F, H and I).

A sensitivity analysis was carried out on the increase in average, annual net farm income for new adopters of climate forecasting and other BMPs contributing to improved management decisions (Table 11). The results showed a low to moderate sensitivity to the assumed increase in average, annual net farm income for QLD beef enterprises.

Table 11: Sensitivity to the Increase in Net Farm Income for New Adopters (Lower Bound Analysis, Total investment, 5% Discount rate, 30 years)

Investment Criteria	**Increase in Net Farm Income for New Adopters**		
	10% (base)	**15%**	**25%**
PVB ($m)	207.17	247.17	327.16
PVC ($m)	40.46	40.46	40.46
NPV ($m)	166.71	206.71	286.70
BCR	5.12	6.11	8.09

A sensitivity analysis also was carried out on the proportion of new QLD beef grazing enterprises adopting climate forecasting and other BMPs contributing to improved management decisions (Table 12). The results showed a low to moderate sensitivity to the proportion of new beef enterprises adopting improved practices due to the DCAP investment.

Table 12: Sensitivity to the Proportion of New Adopters Making Improved Decisions (Lower Bound Analysis, Total investment, 5% Discount rate, 30 years)

Investment Criteria	**Proportion of New Adopters**		
	15% (base)	**25%**	**35%**
PVB ($m)	207.17	260.50	313.83
PVC ($m)	40.46	40.46	40.46
NPV ($m)	166.71	220.04	273.37
BCR	5.12	6.44	7.76

A sensitivity analysis then was carried out on the proportion of the QLD beef industry at risk of a loss of social licence to operate (Table 13). The results showed a low sensitivity to the proportion of the QLD beef industry assumed to be at risk of loss of social licence.

Table 13: Sensitivity to the Proportion of the QLD Beef Industry at Risk of Loss of Social Licence (Lower Bound Analysis, Total investment, 5% Discount rate, 30 years)

Investment Criteria	**Proportion of QLD Beef Industry at Risk**		
	5%	**10% (base)**	**15%**
PVB ($m)	204.77	207.17	209.57
PVC ($m)	40.46	40.46	40.46
NPV ($m)	164.31	166.71	169.11
BCR	5.06	5.12	5.18

Finally, a sensitivity analysis was carried out on the change in risk of loss of social licence attributable to the DCAP Phase 2 investment (Table 14). The results showed a low sensitivity to the assumed change in risk of loss of social licence attributable to the DCAP investment.

Table 14: Sensitivity to the Change in Risk of Loss of Social Licence for QLD Beef Graziers (Lower Bound Analysis, Total investment, 5% Discount rate, 30 years)

Investment Criteria	**Change in Risk of Loss of Social Licence**		
	0.5%	**1% (base)**	**2%**
PVB ($m)	204.77	207.17	211.97
PVC ($m)	40.46	40.46	40.46
NPV ($m)	164.31	166.71	171.51
BCR	5.06	5.12	5.24

5. Conclusions

Eight of the nine DCAP Phase 2 investments analysed provided positive NPVs at a 5% discount rate. The BCRs across these eight investments ranged from approximately 4.0 to 7.6 to 1 for the total investment analysis for the 30-year period from the year of last investment in the Program (2021/22). The highest BCR (7.61) was provided by the DAF9: *Forewarned is Forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events*. However, any direct 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 valuation frameworks used across the eight individual evaluations.

Two sets of aggregate analyses and corresponding investment criteria were reported for the investment in the DCAP Phase 2 Program. One analysis refers to the eight projects that contributed to the impacts that were valued. Total funding for the eight projects where impacts were valued totalled approximately $39.0 million (present value terms) and produced aggregate total expected benefits of $207.2 million (present value terms). This gave an estimated NPV of $168.2 million, a BCR of 5.3 to 1, an IRR of 24.0% and a MIRR of 8.4%. The investment in the eight projects valued represented approximately 96.4% of total funding across the nine DCAP Phase 2 projects evaluated in present value terms.

When the benefits for the impacts valued were compared to the total investment in all nine DCAP Phase 2 projects, this lowered slightly the aggregate investment criteria. Funding for all nine projects totalled approximately $40.5 million (present value terms). When compared to the same value of benefits from the eight projects ($207.2 million), the investment produced an estimated NPV of $166.71 million, a BCR of approximately 5.1 to 1, an IRR of 23.4%, and a MIRR of 8.2%.

Based on the conservative assumptions made in the individual DCAP Phase 2 project evaluations (Appendices A to I), the restriction of the valuation of some benefits to QLD and the beef industry only, and the fact that a number of impacts identified were not valued in monetary terms, the aggregate investment criteria reported are likely to be an underestimate of the true performance of the DCAP Phase 2 Program investment. The analysis indicates that the DCAP Phase 2 Program has delivered, and will continue to deliver, positive impacts to QLD, and Australian, primary industries, Government and the wider community. The results should be viewed positively by DCAP Management, DAF, Australian primary industries and other DCAP funding partners, as well as policy personnel responsible for allocation of public funds.

References

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

Appendices

The following table lists the titles of the individual DCAP project BCA reports that form the appendices to the DCAP Program evaluation.

Table 15: Individual DCAP Project BCA Reports

Project Code	Report Title
DES1	Appendix 1: Inside Edge for graziers to master Queensland's drought-prone climate
DES2	Appendix 2: Do we really know our baseline climate? Using palaeoclimatic data to better plan and prepare for extreme droughts and floods in Queensland
DES3	Appendix 3: Enabling drought resilience and adoption: A program of social research and knowledge support
USQ4	Appendix 4: Innovative drought and climate variability RD&E to enhance business resilience and build producer capacity to manage climate risk across the northern Australian red meat industry
USQ5	Appendix 5: Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2
DAF6	Appendix 6: Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises
DAF7	Appendix 7: The Use of BoM Multi-Week and Seasonal Forecasts to Facilitate Improved Management Decisions in Queensland's Vegetable Industry
DAF8	Appendix 8: Building Drought Resilience (GrazingFutures)
DAF9	Appendix 9: Forewarned is Forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events

Appendix 1: An Impact Assessment of ‘Inside Edge for graziers to master Queensland’s drought-prone climate’ (Project DES1)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research
in conjunction with AgEconPlus

August 2020

Contents

List of Tables and Figures

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Abbreviations

BCR	Benefit-Cost Ratio
BoM	Bureau of Meteorology
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries – Queensland
DCAP	Drought and Climate Adaptation Program
DNRME	Department of Natural Resources, Mines and Energy
DSITI	Department of Science, Information Technology and Information
FLTCC	FORAGE Long Term Carrying Capacity
GVP	Gross Value of Production
IRR	Internal Rate of Return
LCAT	Land Condition Assessment Tool
MIRR	Modified Internal Rate of Return
MLA	Meat and Livestock Australia
NPV	Net Present Value
PGA	Pasture Growth Alert
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current project investment (DES1: Inside Edge) within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP).

The project is described qualitatively using a logical framework that includes project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts are then estimated in dollar terms.

Potential benefits are estimated for a range of time frames up to 30 years from the last year of investment in the project (2020/21). Past and future cash flows in 2019/20 dollar terms are discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) has been conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The investment in the project and its findings and the resulting potential outcomes have been important in improving the application of seasonal forecasting and associated grazing management tools for some Queensland graziers in particular, Queensland beef producers.

The principal impacts identified were of a financial/economic nature with implications for both sustainability and profitability of grazing systems in Queensland. The impacts valued are the contributions to an increased average net income to Queensland beef producers, a contribution to a sustained social licence for Queensland graziers, and a potential reduction in Queensland government support for drought affected regions.

Total funding from all sources over the project duration was approximately $8.08 million (present value terms). The value of total benefits estimated for Queensland beef producers from application of the information and tools delivered by the project was estimated at $46.27 million (present value terms). This result generated an estimated net present value of $38.19 million, and a benefit-cost ratio of 5.73 to 1.

There were several potential impacts identified that were not valued in economic terms. These impacts included the regional community spill-overs from the livestock producer gains emanating from the investment, and the scientific (climate modelling) capability and future capacity built by the investment. The investment criteria reported therefore are likely to have undervalued the full value of benefits delivered by the investment.

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background and Project Summary

Background

Project DES1 set out to help Queensland (QLD) graziers better understand how management decisions can be more climate responsive and assist building greater resilience to climate variability. The existing set of tools being improved and those being developed were to be property specific, utilise the latest seasonal forecasting technologies, and utilise information on land condition and pasture cover data via satellite. The end points of grazier use of such tools were: improved pasture alerts and drought preparedness, improved grazing management decisions including long-term stocking rates, improved catchment water quality, and potentially, improved average annual net income and reduced income variability. Other end points included an assessment of whether simple rules of thumb may exist to enhance climate responsive grazing (via both sorghum feed and grazing system management).

Project Details

The investment in the project assessed is for the years ending June 2018 to June 2021. The Department of Science, Information Technology and Information (DSITI) was the original research agency (now renamed Department of Environment and Science (DES)). Other QLD Government Departments were involved also including the Department of Agriculture and Fisheries (DAF), Department of Natural Resources and Mines, as well as other collaborating institutions including the Northern Territory Department of Primary Industry, the University of Southern QLD and the Bureau of Meteorology (BoM). Information on the Drought and Climate Adaptation Program (DCAP) project code, title, key personnel, and funding period is summarised in Table 1.

Table 1: Summary Details for the Investment

Project Code	Title	Project Leader	Funding Period
DES1 (DSITI 1.0)	Inside Edge for graziers to master Queensland's drought-prone climate	Jacqui Willcocks (DES)	Years ending June 2018 to June 2021

3. Logical Framework

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

Table 2: Logical Framework for Project DES1: Inside Edge for Graziers

Overall Objective	The overall objective of the project is to provide information and improved drought support tools to QLD graziers, including improved information about current conditions and pasture growth in an historical and regional context and improved application of seasonal forecasts in decision support tools.
Specific Objectives	• To assist with phased proactive destocking in the face of drought including evaluation of ACCESS-S and other seasonal forecasts in grazing enterprise management. • To facilitate maintaining optimum livestock numbers for sustainable and profitable use of pasture resources in a variable and changing climate, as well as evaluating the potential impacts of climate change on carrying capacity. • To provide “what-if” scenario capability to potentially improve productivity and/or sustainability by enhancing the utilisation of property resources from fencing to land type, fencing off degraded areas, watering point additions (property redesign especially useful for reef-sensitive grazing), improved pastures and potentially comparative decision making involving regrowth clearing. • To help achieve greater productivity for the Queensland sorghum industry, a major beef industry feedstock, from enhancing varietal selection and seasonal tactical management using ACCESS-S and other forecast technologies. • To review and refine sustainable levels of utilisation for land types learnt from grazier best practice. • To provide on-going delivery of on-ground outcomes through exposure of technology increments to selected collaborative graziers, sorghum growers, DAF drought support officers and regional bodies while maintaining adaptive adjustment of the research program from end-user feedback.
Activities and Outputs	• Collaborative agreement signed in August 2017. • Workshops held on existing science products and applications for DAF extension officers including product support and feedback on tools. • Development of an extension training package for the FORAGE Pasture Growth Alert report (DES) and package delivery via the DAF extension network and promotion through the Long Paddock and FutureBeef websites. This activity was to complement the existing extension training packages for FORAGE reports. • Ensuring improvement and quality assurance for the GRASP pasture growth calculator with enhanced parameters and validation from grazing trials and satellite-derived data. • Improvements to GRASP included: o Pasture yield data collected at a scale relative to remote sensing. o Rapid assessment of biomass using a pasture height meter. o The effect of stocking/utilisation rates on perennial grass composition was built into GRASP and validated. o More historical trials were added to the GRASP database. • As background, FORAGE is an online information system to facilitate best management practice for grazing land. The system provides

	managers with property level information on rainfall, land types, ground cover, soil erodibility, tree density, seasonal climate outlooks and pasture growth simulated using the GRASP model. The information is site-specific and makes information from a range of databases and pasture growth models more accessible and relevant to decisions of land managers (Based on Zhang and Carter, 2018) • A 2018 webinar series, including Long Paddock, pasture growth Posters and the FORAGE tool attracted 15-43 attendees per webinar, with high levels of satisfaction and intention to change practices reported. Webinars continued in 2019 and 2020 (Jacqui Wilcox, pers. comm., 2020) . • Regular updates for policy groups, such as the drought and land management group in DAF, and land value group in DNRME. • Posters on rainfall variability, extended wet and dry periods, and cyclone tracks were developed and received positive feedback from a number of sources. • An on-line tool for comparing a drought declaration map with seasonal conditions leading into that drought declaration period. Previously this information was only available in different parts of the Long Paddock website. The information archive has also been extended back another 30 years to 1964 (Jacqui Willcocks, pers. comm., 2020). • Development of simple protocols for using seasonal forecast information and the communication of such rules of thumb to beef extension officers, producers and consultants via the development of the Pasture Growth Alert (PGA). • The PGA assembles key rules of thumb and then adds management suggestions with the associated level of risk. The PGA has an effective combination of rules of thumb namely: 1. where are we at now? (Pasture growth for the last 12 months compared with historical values); 2. What is the future looking like based on seasonal climate forecasting? (Pasture growth outlook for the next 6 months, compared with historical values) and 3. What is the ground cover looking like / how resilient is the pasture? (last month's ground cover derived from satellite images, compared to historical values) (Jacqui Willcocks, pers. comm., 2020). • The FORAGE PGA report and other FORAGE reports have been made available to producers via subscription to the Long Paddock website. • The project developed an extension training package for the FORAGE Long Term Carrying Capacity (FLTCC) report and its delivery via extension, together with promotion via the Long Paddock and FutureBeef websites. • The project contributed further enhancement of the FLTCC report to enable users a "what-if" evaluation of changing property layouts, land condition and area of sown pasture to assess management decisions and climate change impacts. • Other improved aspects of FORAGE contributed by the project included: o Checking land type parameterisation for the GRASP component of the model. o Accommodating changes in land condition due to changes in botanical composition. o Better integration of satellite derived data, such as changing from seasonal ground cover to the most recent month ground cover,

	making FORAGE reports which use satellite-derived ground cover more time-relative. o Improving the modelling where there were advances in knowledge, for example better representation of soil evaporation, transpiration from grasses and transpiration from trees (Jacqui Willcocks, pers. comm., 2020). • The project made an evaluation of climate responsive stocking rate decisions including evaluating the utility of forecasts made by the BoM's ACCESS-S. • The project completed further quality assurance of GRASP and FORAGE models with emphasis on liveweight gain, runoff and soil loss; this stage included a documented procedure for management of the DAF/DES land type parameters. • The project enabled users to provide property-specific information to improve the accuracy of carrying capacity by including land condition assessments, forage preference and information guided by the Land Condition Assessment Tool (LCAT) and other satellite-derived ground cover products. • Integration with other modelling work was undertaken with DCAP Project DAF 6 "Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing systems". • Worked with DCAP DES 3 to produce an animation explaining percentiles which are used in many of the seasonal outlooks and Long Paddock products. • Engagement was facilitated between graziers and consultants to review sustainable levels of utilisation and expansion of the existing network of benchmark properties beyond western QLD. • Development of an extension training package for enhanced forage budgeting and its delivery through the DAF extension network and further promotion via the Long Paddock and FutureBeef websites to complement the existing extension training packages (anticipated during June 2020- May 2021). • FORAGE Seasonal Forage Budgeting report enhanced with satellite-derived information available on the Long Paddock website including testing and evaluation by DAF extension officers (anticipated during August 2020 - May 2021). • The sorghum sub-component of the project has contributed research findings, but it will be published as part of a larger assessment looking at temperature impacts that have implications for the industry's seasonality. That is, the subcomponent is assessing both temperature and rainfall on the sorghum planting window. The results show that ACCESS-S is not any better at forecasting the seasonal sorghum yield than the previous BoM system (POAMA). However, ACCESS-S is pretty good at the coming week and useful for planting windows. We are finding that ACCESS-S is better 'most of the time', but it gets it completely wrong when the industry cannot afford to get it wrong, so the project is using the older systems, at this stage (Jacqui Willcocks, pers. comm., 2020). • Final project report (anticipated by June 2021).
Outcomes	• Improved understanding of the applicability and use of seasonal climate forecasting by advisors and QLD graziers resulting in adjustments to stocking management levels and strategies.

	• Improved quality of information and access to information about current climate conditions in Queensland grazing lands, including drought sequence viewer, FORAGE reports, and AussieGRASS (Jacqui Willcocks, pers. comm., 2020). • Increased value of use of seasonal climate forecasting due to better understanding and awareness of current conditions, based on improved pasture-modelling capacity and performance. • Potential increase in use by QLD advisors and graziers of FORAGE seasonal budgeting reports, the FORAGE Pasture Growth Alert reports and the Long Term Carrying Capacity reports, all to assist with grazing and livestock management decisions. • Potentially, improved utilisation of sorghum feedstock from improved varietal selection and management using seasonal forecasts. • Availability and use of the PGA (climate and pasture growth plus seasonal forecasting and pasture resilience as indicated by ground cover percentiles) by advisors and graziers that assist with climate responsive grazing management. • Improved information available to policy groups, such as the drought and land management group in DAF, and land value group in DNRME. • Usage of information produced by regional communities and the Queensland Government in regional drought declarations and approvals.
Impacts	• Increased annual average productivity and profitability of some QLD graziers through improved management decisions. • Reduced variability of annual net income by some QLD graziers • The productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. • Improved land condition and sustainability including decreased soil loss of some pastoral properties and reduced soil runoff to external environments. • Potential for a reduction in costs of drought support by Queensland government to QLD graziers. • Maintenance of social licence for grazing activities in pastoral Queensland. • Spillovers to regional communities from increased and less variable incomes for QLD livestock producers and their associated supply chain businesses. • Reduced stress experienced by pastoral system managers. • Maintained/increased QLD applied modelling capability and capacity associated with grazing management, and ensuring capacity is current through increasing testing and use of remotely-sensed data, backed up by field-collected data (Jacqui Willcocks, pers. comm., 2020).

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Table 3 shows the annual investment in the project by contributing organisation.

Table 3: Annual Investment by Contributor for Years ended June (nominal $)

Year	2018	2019	2020	2021	2022	Total
DAF (cash)	603,456	603,456	603,456	603,456	0	2,413,824
QLD Reef Water Quality Program	0	540,000	595,000	550,000	520,000	2,205,000
Other Agencies (cash and in-kind)	779,297	816,544	830,320	828,624	0	3,254,785
Totals	1,382,753	1,960,000	2,028,776	1,982,080	520,000	7,873,609

Source: Jacqui Willcocks (DES) and Neil Cliffe (DCAP, DAF)

Program Management Costs

It has been assumed that any management and administration costs for the funding organisations have already been included in the nominal $ amounts appearing in Table 3.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20 $ terms using the Implicit Gross Domestic Product Deflator index (ABS, 2020).

5. Impacts

A summary of impacts in a triple bottom line categorisation is shown in Table 4.

Table 4: Categories of Impacts from the Investment

Economic	Environmental	Social
Increased average annual productivity and profitability of some Queensland graziers. Reduced variability of annual net income by some QLD graziers from improved management decision making (e.g. destocking, restocking) that takes into account seasonal climate forecasts and condition of pasture resources. Any productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. Maintenance of social licence for grazing activities in pastoral Queensland. Potential reduction in costs of drought support by Queensland government to QLD graziers.	Improved land condition (the ecosystems in grazing lands) Reduced soil loss and Improved catchment water quality through reduced soil and nutrient export from QLD pasture areas.	Reduced stress experienced by grazing system managers. Spill-overs to regional communities from increased and less variable incomes for QLD livestock producers and their associated supply chain businesses. Maintained/increased QLD applied modelling capability and capacity associated with grazing management.

Distribution of Producer Impacts along the Supply Chains

Some of the potential benefits from the maintained/increased productivity/profitability of QLD producers will be shared along the supply chain with processors, exporters and consumers.

Public versus Private Impacts

The impacts identified from the investment are predominantly private, namely accruing to QLD livestock producers and their supply chains. Some public benefits will be produced including increased sustainability of livestock production including reduced soil loss and improved quality of water exported from farms, increased spill-overs to regional communities from improved drought management and reduced income variability, as well as increased scientific capacity.

Impacts Overseas

It is unlikely that there will be any significant impacts overseas.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 5. The investment is relevant to Rural RD&E Priorities 1, 3 and 4 and to Science and Research Priority 1, 2 and 7.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[a] (est. 2015)	**Science and Research Priorities[b] (est. 2016)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2016)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision-making around future investment are reproduced in Table 6.

The investment addressed QLD Science and Research Priority 1, 2, 3 and 6. In terms of the guides to investment, the investment is likely to have a real future impact through improved management of drought delivering both private and public impacts. The project was well supported and funded by a range of organisations, many external to the QLD Government and had a distinctive angle as QLD livestock producers and regional communities will be major recipients of the impacts.

Table 6: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally-enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Queensland Chief Scientist (2015)

6. Valuation of Impacts

Impacts Valued in Monetary Terms

The three impacts valued in the quantitative analysis are:

- Increased annual average productivity and profitability of some QLD graziers through improved management decisions.
- Maintenance of social licence for grazing activities in pastoral Queensland.
- Potential for a reduction in costs of drought support by Queensland government to QLD graziers.

The DES1 project evaluation forms part of a broader assessment of the DCAP Phase 2 investment. Two of the impacts identified above (increased productivity/profitability and decreased risk of a loss of social licence for the QLD grazing industry) were valued at a DCAP Program level. Six DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to these two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

i. Though some benefits from the six contributing projects would accrue to graziers in the NT and the north of Western Australia (WA), the main emphasis of the DCAP projects was in QLD,
ii. The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising 49.8% of the national heard of 22.4 million head (ABS, 2020). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and
iii. The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

It should be noted that the impacts valued for the Queensland beef industry would be a substantial component of all impacts delivered by the improved climate risk management and the contribution to social licence maintenance. However, mixed grazing enterprises have not been included nor have the benefits to beef producers in the Northern Territory and the north of Western Australia.

The third impact identified above for DES1 has been valued jointly in the quantitative analysis with two other projects including DES3 and USQ4.

A summary of all assumptions is presented in Table 7.

Table 7: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
IMPACT 1: Increased profitability/ productivity for QLD grazing enterprises (increased net farm income for QLD beef producers)		
Without DCAP 2 investment		
Average farm cash income for QLD beef producers	$163,645 per farm	5yr average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (ABARES, 2020)
Average number of beef cattle enterprises in QLD	7,069	5yr average based on AgSurf population data for QLD beef

		(2015 to 2019) (ABARES, 2020)
Current proportion of primary producers in QLD utilising climate forecasting, models, decision support tools etc. for farm decision making	40% Midpoint of most recent estimate: Coban (2017)	Seasonal climate forecasts are used by 30 to 50% of agricultural producers in decision-making (Keogh et al., 2005; Keogh et al., 2004a; Australian Government Department of Agriculture Fisheries and Forestry, 2004) The uptake of SCF by agricultural producers in decision making ranges from 30 to 50% (Cobon et al 2017)
With DCAP2 Phase 2 investment		
Part 1 (existing users: Proportion of existing users (primary producers) of climate forecasting, models, decision support tools who have improved their decision making specifically due to DCAP Phase 2 investment	25%	¼ of existing users in QLD, conservative analyst assumption
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	5%	Conservative estimate based on a minimum profitability/ productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).

Part 2 (new users): Proportion QLD beef producers newly adopting the use of climate forecasting, models, decision support tools etc. to improve on-farm decision making	15% (increasing proportion of total QLD users from 40% to 55%)	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Risk factors		
Probability of output.	100%	Outputs have already been delivered
Probability of outcome	100%	Already allowed for in the 33% of QLD beef enterprises implementing practice changes on farm
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future
Contribution to relevant DCAP projects from DES1		
Specific attribution to DES1	23%	DES1 investment as % of total investment in DES1, DES3, USQ4, DAF6, DAF8 and DAF9
IMPACT 2: Maintained social licence to operate for some QLD grazing enterprises (QLD beef producers)		
Baseline data		

Average annual gross value of production (GVP) of QLD beef cattle	$5,206.2 million	5yr average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019)
With investment in DCAP projects DES1, DES3, USQ4, DAF6, DAF8 and DAF9		
Profit as a proportion of GVP	10%	Analyst assumption, based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data 2017 to 2019) (Australian Bureau of Agricultural and Resource Economics and Sciences, 2020)
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment	10%	Analyst assumption
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment	1.0%	Conservative estimate, analyst assumption
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm
Year of maximum impact	2024/25	Five years from first year of impact
Risk factors		
Probability of output	100%	Outputs have already been delivered
Probability of outcome	100%	Already allowed for in the 10% of QLD beef enterprises at risk
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future
Contribution to relevant DCAP projects from DES1		
Specific attribution to DES1	23%	DES1 investment as % of total investment in DES1, DES3, USQ4, DAF6, DAF8 and DAF9
IMPACT 3: Contribution to reduced cost to Queensland government for drought support		
Average QLD drought support costs	$27 million per annum	Based on Wade and Burke (2019)
Reduction drought support costs due to DCAP investment	9%	Analyst assumption, based on combined impact of DES1

		(4%), DES3 (1%), and USQ4 4%
First year of reduction	Year ending June 2022	Analyst assumption
Year of maximum reduction	Year ending June 2026	Analyst assumption
Risk and attribution factors		
Probability of relevant output	100%	Analyst assumptions
Probability of outcomes occurring given information generated	75%	
Probability of impact given outcomes	75%	
Specific attribution to Project DES1	4%	

Counterfactual

The counterfactual Includes a scenario that some climate knowledge and seasonal forecasting tools would have been utilised by graziers without the investment in DES1. This scenario is allowed for in the valuation by considering only the improvements in such tools as well as their increased availability and promotion through activities in DES1 and its associated projects, including delivery projects.

Impacts not Valued in Monetary Terms

The impacts identified but not valued included:

- The increased spillovers to regional communities from sustained or increased income and decreased income variability was not valued as any increased economic activity and employment along the product supply chain would be difficult to value, given the number and spread of production systems, subregions, and the availability of time and resources for valuation.
- The impact of reduced income variability was not valued as measures of the current level of income variability were not readily available; furthermore, it is difficult to convert any reduced variability into simple $ terms without knowledge, for example, of interest rates that may apply to surplus investment in good years versus increased loans in poor years.
- The impact of a reduction in environmental damage would be difficult to value given the differences in regional ecosystems, the sometimes localised nature of drought, and the fate of the soil and nutrient losses off-farm
- Maintained/increased QLD scientific and applied climate forecasting capacity would be difficult to value but some of the new capacity built will be accounted for in the improved climate modelling and tools already developed and valued in the existing analysis.

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Tables 8 and 9 show the investment criteria estimated for different periods of benefits for the total investment and the DAF DCAP investment respectively. The present value of benefits (PVB) attributable to DAF DCAP investment only, shown in Table 9, has been estimated by multiplying the total PVB by the DAF DCAP proportion of total project investment (31%).

Table 8: Investment Criteria for Total Investment in the DES1: Inside Edge

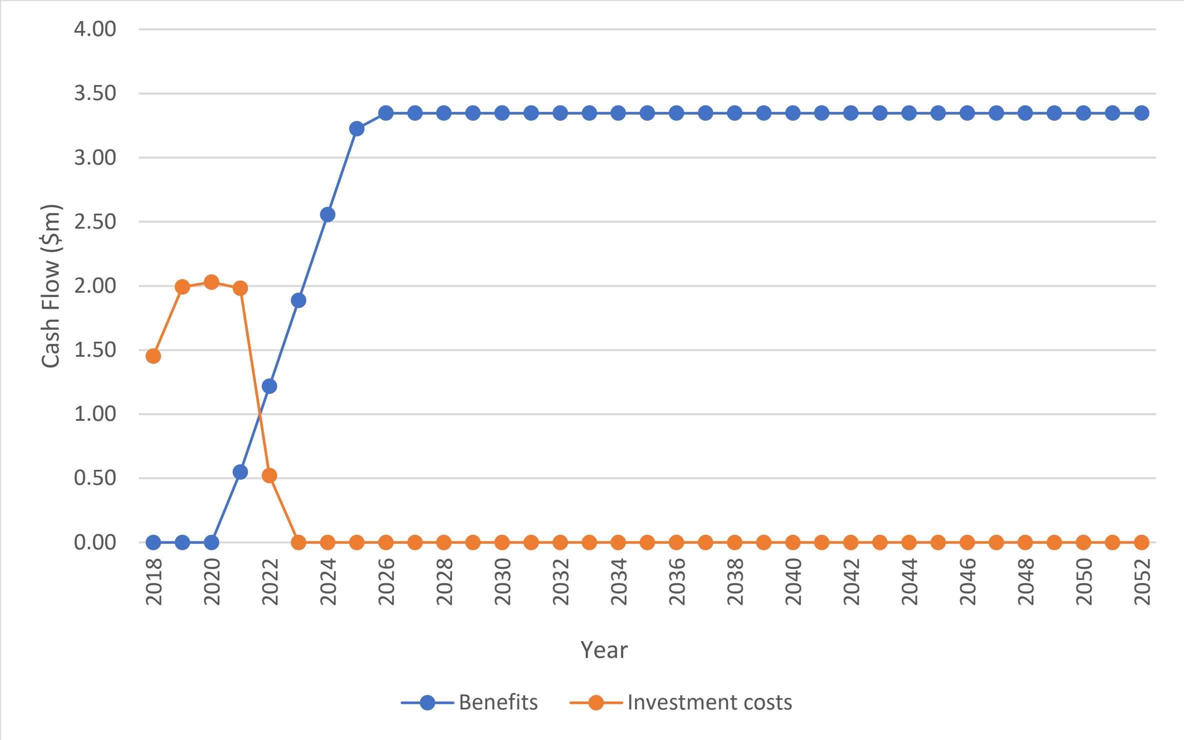
Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	1.63	12.76	23.05	31.12	37.44	42.39	46.27
Present value of costs ($m)	8.08	8.08	8.08	8.08	8.08	8.08	8.08
Net present value ($m)	-6.46	4.68	14.97	23.04	29.36	34.31	38.19
Benefit-cost ratio	0.20	1.58	2.85	3.85	4.63	5.25	5.73
Internal rate of return (IRR) (%)	negative	15.13	22.64	24.27	24.72	24.86	24.91
Modified IRR (%)	negative	10.47	16.13	15.09	13.75	12.62	11.21

Table 9: Investment Criteria for DAF DCAP Investment in DES1: Inside Edge

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.50	3.93	7.09	9.57	11.52	13.04	14.24
Present value of costs ($m)	2.52	2.52	2.52	2.52	2.52	2.52	2.52
Net present value ($m)	-2.02	1.40	4.57	7.05	9.00	10.52	11.72
Benefit-cost ratio	0.20	1.56	2.81	3.80	4.57	5.17	5.65
Internal rate of return (IRR) (%)	negative	14.28	21.61	23.26	23.73	23.88	23.93
Modified IRR (%)	negative	9.48	14.90	14.13	12.99	11.99	10.20

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

Figure 1: Cash Flow of Undiscounted Total Net Benefits and Total Investment Costs



Source of Benefits

Estimates of the relative contribution of each benefit valued, given the assumptions made, are shown in Table 10.

Table 10: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Increased beef producer profitability	36.97	79.9%
Maintenance of social licence	1.33	2.9%
Reduced cost of QLD Government drought support	7.97	17.2%
Total	46.27	100.0%

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 11 presents the results that showed a moderate sensitivity to the discount rate.

Table 11: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	99.76	46.27	25.86
Present value of costs ($m)	7.98	8.08	8.21
Net present value ($m)	91.79	38.19	17.65
Benefit-cost ratio	12.51	5.73	3.15

Other sensitivity analyses including the sensitivity of assumptions for valuing Impacts 1, 2 and 3 are carried out at the Program level due to the valuation frameworks being extended to cover multiple projects. This was driven by the pathways to impact being common to each of the three impacts.

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 12). 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 12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium-High	Medium

Coverage of benefits was assessed as Medium-High. While there were several benefits identified but not valued, the principal economic impacts delivered by the project (the increase in average net beef producer income, the protection of the social licence, and the reduced cost of drought to government were all valued.

Confidence in assumptions for the valuation was rated as Medium as some of the assumptions associated with the increased average income and the reduction in the social licence risk and the reduction in the government drought costs were somewhat uncertain.

8. Conclusion

Together with other current DCAP projects, the investment in DES1 (Inside Edge) has made a major contribution to the productivity, profitability and environmental sustainability of the Queensland grazing industry. DES1 was funded over the years ending 30th June 2018 to June 2022.

The benefits delivered by the project will accrue predominantly to Queensland graziers. Some of these benefits are likely to be shared along the product supply chain due to increase economic activity in product transporting and processing. Some public benefits will be delivered via community spillovers from increased, or at least maintained, producer incomes

In summary, the total investment in the project of $8.08 million (present value terms) has been estimated to produce total gross benefits of $46.27 million (present value terms) providing a net present value of $38.19 million, a benefit-cost ratio of 5.73 to 1 (using a 5% discount rate), an internal rate of return of 24.9% and a modified internal rate of return of 11.2%.

The investment criteria reported are likely to have slightly undervalued the full set of impacts delivered by the investment. This was because several benefits identified were not valued. For reasons explained in the assessment, benefits accruing to reduced income variability, benefits to mixed grazing enterprises, and specific environmental and natural resource impacts were not included in the valuations. Also, the regional community spillover impacts arising from the livestock producer impacts, nor the increased/maintained capability and capacity regarding climate forecasting delivered by the investment, were not valued.

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Appendix 2: An Impact Assessment of ‘Do we really know our baseline climate? Using palaeoclimatic data to better plan and prepare for extreme droughts and floods in Queensland’ (Project DES2)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research
in conjunction with AgEconPlus

August 2020

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Abbreviations

ACE	Antarctic Climate and Ecosystem Cooperative Research Centre
ARC	Australian Research Council
BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries – Queensland
DCAP	Drought and Climate Adaptation Program
DES	Department of Environment and Science - Queensland
DSITI	Department of Science, Information Technology and Information
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
SE	South East

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current investment in a project within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP).

The project is described qualitatively using a logical framework that included project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Potential impacts were not valued in monetary terms.

The investment in the project and its potential findings are likely to be important in strengthening the understanding of Queensland water agencies in relation to the occurrence of severe floods and droughts that preceded the current 120 years of available climate records.

The added information on the risk of extreme drought and flood occurrence will be particularly relevant to Seqwater and water regulators in managing water resources in the south east of Queensland

Total funding from all sources over the project duration was approximately $1.46 million (present value terms).

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework. Identified impacts were not valued in monetary terms for this investment as the use of the palaeo data can be politically sensitive, particularly when the project is still incomplete.

2. Background & Rationale

Current approaches to risk management climate forecasts of extreme events (e.g. droughts and floods) are based on a short series of Australian historical records (up to 120 years). The associated tools so derived for assisting risk management decisions in relation to droughts and floods will not be accurately representing the full range of risk.

It is generally accepted that the current baseline of extreme flood and drought events based on 120 years of records may not be representative of a wider period. For example, there is evidence that more severe droughts than experienced and recorded in the past 120 years have occurred in Australia in previous periods.

Decisions Associated with Extreme Climate Events
The water management agencies in south east (SE) Queensland (QLD) are particularly concerned about long-term planning that takes into account the likelihood of extreme drought and flood events given the expected future population increase in SE QLD.
Risk management preparedness decisions regarding extreme climate events may encompass both capital investment in infrastructure well in advance of the extreme event as well as operational management decisions in proximity to, and during, the event.

Previous Projects
The current project extends information provided in two previous projects:

1. An Australian Research Council (ARC) Linkage Project (The Big Flood- will it happen again?) (ARC, 2017). The project received funding from the QLD Department of Science, Information Technology and Information (DSITI), Seqwater and the Lockyer Valley Regional Council. This project was aimed at enhancing understanding of extreme floods in SE QLD.
2. A one year pilot study previously funded via the Drought and Climate Adaptation Program (DCAP) (Phase 1) trialled the incorporation of palaeoclimate data into the SE QLD Regional Stochastic Model of catchment hydrology for the Lockyer Catchment (Kiem et al, 2017).

What was Needed
The current project set out to assist QLD decision makers (both public water agencies, water regulators and irrigators) to better understand how management preparedness can assist in improving decisions to prepare for, and manage, extreme climatic events.

The first step in the project was to assess if improvements in current knowledge of extreme climate events could be made by assembling and interpreting palaeo information. Such knowledge could then potentially be used to improve assumptions on extreme climatic events and related decisions on preparedness, including investment and operational management to address extreme events (both floods and droughts).

Seqwater
Seqwater delivers water supply for 3.2 million people across South East Queensland. In addition, Seqwater provides irrigation water to irrigators, flood mitigation services, catchment management and recreation facilities. Seqwater manages up to $11 billion of bulk water supply infrastructure including the SEQ Water Grid. These assets includes dams, weirs, conventional water treatment plants, reservoirs, pumps and pipelines and climate resilient sources of water through the Gold Coast Desalination Plant and the Western Corridor Recycled Water Scheme. New sources of water will be required to meet the future needs of the growing population in the region in the South East (Seqwater, 2016).

3. Project Details

The investment in the project DCAP DES2 is for the years ending June 2018 to June 2021. DSITI, renamed the Department of Environment and Science (DES), is the lead research agency. However, there are a number of other research providers and agencies involved including Southern Cross University, University College Dublin, the University of Newcastle, University of QLD, University of Southern QLD, the Antarctic Climate and Ecosystem Cooperative Research Centre (ACE), the Australian Antarctic Division, Seqwater and Sunwater. The DCAP project code, title, key personnel, and funding period are summarised in Table 1.

Table 1: Summary Details for the Investment

Project Code	Title	Project Leader and Team personnel	Funding Period
DES2	Do we really know our baseline climate? Using palaeoclimatic data to better plan and prepare for extreme droughts and floods in Queensland.	Ramona Dalla Pozza, formerly QLD Department of Environment and Science (DES) and currently Project Leader, Department of Environment, Land, Water and Planning (DELWP), Victoria. Prof Jacky Croke, formerly Southern Cross University and Project Leader, and currently University College Dublin, Ireland. Prof Andrew Parnell is Hamilton Professor in the Hamilton Institute at Maynooth University. Dr Niamh Cahill at Maynooth University. Dr John Vitkovsky, QLD Department of Environment and Science. Wendy Auton, and Paul Fisher and Kate Smolders, Seqwater. Dr Benjamin Henley, Melbourne University.	Years ending June 2018 to June 2021

4. Logical Framework

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

Table 2: Logical Framework for Project DES2: Palaeo Data

Overall Objective	The overall objective of the project is to provide key data sets in order to evaluate the risk of future droughts and floods.
Specific Objectives	• To demonstrate the utility of a palaeoclimate multi-proxy approach in producing catchment baseline climate statistics for managing climate impacts and decision making; • To gain improved insights into the characteristics and risk of hydroclimate extremes in Queensland for water security planning; • To deliver optimised solutions for hydroclimatic risk adaptation strategies to water managers; • To develop data at a regional level that is useful to producers and other groups by a more statistically sound assessment of what is normal versus extreme; • To work with Industry to design and deliver effective solutions for hydroclimatic risk adaptation strategies that are both optimal and robust in the presence of multi-decadal variability and uncertainty, and incorporate this into water security planning, flood/drought management and climate change adaptation in Queensland.
Intended Activities and Outputs	• The development of an online time series database covering rainfall, floods and droughts for QLD for the past 2,000-3,000 years. • The database included both temporal and spatial data for central and southern QLD and could be used to evaluate general drought/flood risk. • Provision of stochastically-generated information showing the hydroclimatic variability across a number of sites for one water catchment (e.g. Callide Basin). • Development and provision of high-resolution data sets from selected sites across southern and central QLD. • Annual workshops held involving researchers, partners and other stakeholders. • Application of the data for a test case of water security planning by modelling of a specific catchment, potentially the North Pine catchment (Kate Smolders, pers. comm., 2020). • It is presumed this will involve use of the data for stochastic modelling over multiple iterations. • The stochastic modelling will include annual, multi-year and multi-decadal data. • The data on hydroclimatic variability are being used to re-evaluate drought risk at various case study locations in light of the millennial-scale variability based on the palaeoclimatic records. • For droughts, parameters being assessed include the frequency of dam levels below certain levels (minimum operating level, restriction levels, etc.), and failure to supply water to users/irrigators/environment (Ramona Dalla Pozza, pers. comm., 2020). • For floods, intended future outputs are flood level/risk maps showing areas of inundation, for example, a 1 in 100 year event (Ramona, Dalla Pozza, pers. comm., 2020). • Delivery of a draft project report. • Delivery of a final project report in June 2021.

Outcomes (Usage of information)	Capital investment • The re-evaluation of drought/flood risk may be able to address capital investment decisions by stochastic modelling (e.g. to inform decisions around timing for system augmentation, such as new water sources and upgrades (Kate Smolders, pers. comm., 2020). • This could lead to improved capital investment strategies that accommodate risk of future extreme events (extreme droughts and/or floods). • Seqwater has developed a Water Security Program to secure south-east QLD with drinking water over the next 30 years (Seqwater, 2016). • New Sources of water will be required to meet future needs and therefore Seqwater will need to continue to invest in water infrastructure to better manage demand peaks in severe droughts (Seqwater, 2016). For example, this could mean: • Higher capital investment that is economic in the long term due to lower impact and reduced management costs when extreme events occur in future, given the palaeoclimate data and revised extreme event risk. • Changes to location, number and design of new water sources that may have sub-optimal use in most years but nevertheless, are beneficial in the long term due to their contributions when compared with the revised extreme risks. • Seqwater's revised drought response plans aim to minimise costs and improve water security during drought (Seqwater, 2016); the palaeo data will be helpful in achieving this objective. • Further, changes may be made to the timing of when Seqwater drought readiness messaging will start (e.g. the commencement of water restrictions and the timing of deployment of the Western Corridor Recycled Water Scheme) • The dataset will increase the accessibility of palaeoclimate data so that it could be used in combination with historical and future climate change data to make robust decisions; for example, the data could be used to assist size of storage decisions in the development of new private water storages in future (in addition to assisting Seqwater). Other uses • The current modelling is oriented mostly for droughts. Some Seqwater analyses require the calculation of failure rates out to a 1 in 10,000 year event. Data are extrapolated out to this frequency, so reducing uncertainty of these extreme, low frequency events (Ramona Dalla Pozza, pers. comm., 2020). • The palaeoclimate data are not likely to be used in the short term for decadal/multi-year/seasonal climate forecasting so that the usefulness of such forecasts is increased; however, such uses could be developed in the future. • A more general outcome is that the palaeoclimate data would improve understanding of the natural climate variability; such improved understanding could lead to a range of other impacts. • Another potential outcome of the development of the database is that it might assist irrigator planning for extreme droughts; for example, if the current data suggest that the chances of a long-term drought occurring in SE QLD (or for a specific catchment) is once every 100 years, and the new data may suggest it is now more accurately

	predicted to be once in 75 years, then irrigators will be able to take this into account in land management e.g. be more wary of using entitlements /choose less water-risky enterprises. • For the water resource regulator (Queensland Department of Natural Resources, Mines and Energy) and Seqwater, changes in policies could involve buying out of some smaller irrigators, building new infrastructure, encourage greater water use efficiency, etc. (Ramona Dalla Pozza, pers. comm., 2020). • The approach taken in the project is likely to provide a model, both in Australia and globally, for the way that palaeoclimate datasets are assembled in one spot for analysis.
Impacts	• The range of impacts delivered by the outcomes above will depend on the framework for decision makers who benefit, and the specific decisions that the new data are expected to influence. Specific impacts could include: • Reduced net economic and social losses from extreme climatic events due to improved capital investment planning and operational management for Seqwater water sources and associated risk management planning by irrigators. • Potential for reduced vegetation, soil, and wildlife loss and damage due to improved planning for extreme climate events. • Reduced personal and community trauma and improved wellbeing. • Increased scientific capability and capacity.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

5. Project Investment

Table 3 shows the annual investment in the project by a range of organisations.

Table 3: Annual Investment for Years ended June (nominal $)

Year	2018	2019	2020	2021	Total
DAF (cash)	100,000	100,000	100,000	100,000	400,000
Seqwater (cash)	0	100,000	100,000	100,000	300,000
Seqwater (in kind)	0	60,000	60,000	60,000	180,000
University College Dublin (in kind)	0	100,000	100,000	100,000	300,000
DELWP (Vic) (in kind)	0	13,500	13,500	13,500	40,500
QLD DES (in kind)	0	25,038	25,038	25,038	75,114
Maynooth Uni (in kind)	0	45,000	45,000	45,000	135,000
Totals	100,000	443,538	443,538	443,538	1,430,614

Source: Original proposal updated with assistance from Ramona Dalla Pozza

The ACE contribution and the University of Newcastle contributions have already been invested anyway and do not form part of the DES2 investment. As these contributions have contributed to the impacts, they are recognised via an attribution factor applied to the benefits valued (see later).

Program Management Costs
It is assumed that any management and administration costs for the project are already built into the nominal $ amounts appearing in Table 3.

Real Investment and Extension Costs
For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20 $ terms using the Implicit Gross Domestic Product Deflator index (ABS, 2020).

6. Impacts

Economic Impact

- Future economic gains/avoided losses from improved information on the risk of droughts and floods leading to improved water security planning for drought and flood periods including:
  (a) improved investment decisions associated with capital investment (e.g. new sources of water for drought periods) by Seqwater.
  (b) Improved operational management decisions by water managers, water regulators, and irrigators.

Environmental Impact

- Potential for reduced vegetation, soil, and wildlife loss and damage due to improved planning for extreme climate events.

Social Impact

- Reduced personal and community trauma and improved wellbeing.
- Increased scientific capability and capacity.

Public versus Private Impacts

The impacts identified from the investment are expected to be largely public. Public benefits will be captured by public water management agencies (both investment and operational management decisions) and potentially via spill-overs to regional communities from better managed extreme droughts and floods, reduced vegetation, soil, and wildlife loss, reduced personal and community trauma and improved wellbeing, and increased scientific capability and capacity.

Impacts Overseas

It is unlikely that there will be any significant direct impacts overseas. However, there may well be useful future overseas impacts flowing from the investment in providing a model globally for the way palaeoclimate datasets are collected in one spot for analysis.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 4. The investment is relevant to Rural RD&E Priorities 1, 3 and 4 and to Science and Research Priority 2.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[(a)] (est. 2015)	**Science and Research Priorities[(b)] (est. 2016)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2016)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision-making around future investment are reproduced in Table 5.

The investment addressed QLD Science and Research Priority 3, 6, and 9. In terms of the guides to investment, the investment is likely to have a real future impact through improved management of extreme climate events. The project was well supported and funded by a range of organisations, many external to the QLD Government and had a distinctive angle as QLD communities will be a major recipient of the impacts.

Table 5: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally-enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

7. Valuation of Impacts

The activities and outputs produced to date by the palaeo data project show that there are potential implications and improvements to future water sourcing, capital investment, and operational water management and regulation. The major impact of the project would be the net economic gain from utilisation of any new risk assessments provided by the additional palaeo climate data and any associated changes in investment preparedness and operations by Seqwater, as well as by water regulators in South East Queensland (Department of Natural Resource, Mines and Energy). The new palaeo data may allow greater accuracy in levels of new investment required as well as other planning and operational management options for the future occurrence of extreme floods and droughts.

However, the palaeo data project is a complex and politically sensitive project on which to place values on impacts, particularly when the project is still incomplete. Hence, there is no attempt to value the impact from this investment in monetary terms in this impact assessment.

8. Results

Investment Criteria Based on Investment Costs
For completeness across the DCAP projects evaluated in 2020, it was necessary to estimate the present value of the costs of the investment in DES2. The annual costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2020). The costs were discounted to 2019/20 using a discount rate of 5%. As for other project investments, the present value of costs was estimated for both the total investment and the DAF investment. The resulting investment criteria are reported in Tables 6 and 7.

Investment Criteria
Tables 6 and 7 show the investment criteria estimated for different periods of benefits for the total investment and the DAF investment respectively.

Table 6: Investment Criteria for Total Investment in the Project DES2

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Present value of costs ($m)	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Net present value ($m)	-1.46	-1.46	-1.46	-1.46	-1.46	-1.46	-1.46
Benefit-cost ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal rate of return (IRR) (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Modified IRR (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7: Investment Criteria for DAF Investment in the Project DES2

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Present value of costs ($m)	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Net present value ($m)	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
Benefit-cost ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal rate of return (IRR) (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Modified IRR	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9. Conclusion

Assuming the investment in the palaeo data development is successful in delivering useful risk information that is used, the investment will have provided positive impacts for QLD south east communities and producers. The benefits delivered by the project will accrue initially to Seqwater and other water agencies and then flow through to communities in the South East of Queensland.

In summary, the total investment in the project of $1.46 million (present value terms) is deemed to have been a very worthwhile investment but it has not been possible to value the potential impact that might arise from use of the palaeo data.

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Appendix 3: An Impact Assessment of 'Enabling drought resilience and adaptation: A program of social research and knowledge support' (Project DES3)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research
in conjunction with AgEconPlus

August 2020

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Abbreviations

ABS	Australian Bureau of Statistics
BCR	Benefit-Cost Ratio
BMP	Best Management Practice
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries – Queensland
DCAP	Drought and Climate Adaptation Program
DES	Department of Environment and Science
GDP	Gross Domestic Product
IRR	Internal Rate of Return
MERI	Monitoring, Evaluation, Reporting and Improvement
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
NSW	New South Wales
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
USQ	University of Southern Queensland

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
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Modified Internal Rate of Return (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current project investment (DES3, *Enabling drought resilience and adaptation: A program of social research and knowledge support*) within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP).

The project is described qualitatively using a logical framework that includes project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts are then estimated in dollar terms.

Potential benefits are estimated for a range of time frames up to 30 years from the last year of investment in the project (2020/21). Past and future cash flows in 2019/20 dollar terms are discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) has been conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

Together with other DCAP projects, the investment in DES3 has made a positive contribution to the productivity, profitability, and environmental sustainability of the QLD grazing industry. Three principal impacts were valued: increased productivity and profitability on QLD grazing enterprises (increased net farm income for QLD beef producers); contribution to reduced cost to QLD government for drought support; and decreased environmental damage, resulting in the maintenance of the QLD grazing industry's social licence to operate.

Total funding from all sources over the project duration was approximately $0.75 million (present value terms). The value of total benefits estimated from the tools delivered by the project was estimated at $4.40 million (present value terms). This result generated an estimated net present value of $3.66 million, and a benefit-cost ratio of 5.91 to 1.

There were several potential impacts identified that were not valued in economic terms. The investment criteria reported therefore are likely to have undervalued the full value of benefits delivered by the investment.

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background & Rationale

Background

As part of the first round of DCAP projects, the Department of Environment and Science (DES) social scientists interviewed specialist grazing service providers and a small number of leading graziers, to identify the main factors that drive or limit drought preparedness and management. The specialist service providers were chosen based on their degree of involvement with graziers in planning, preparing and managing for drought from either a productivity (e.g. agronomists, BMP officers, grazing supply chain processers and retailers) or profitability (e.g. bank managers, accountants, farm financial counsellors) perspective. Factors identified included graziers' and their enterprises': production system; financial situation; management focus; personal circumstances; knowledge, skills, and experience; as well as government involvement. In addition, there were accounts of social factors – such as, cultural understandings of drought as a crisis, rather than a predictable climatic event, requiring a proactive management response. Such understandings arguably contributed to disempowering beliefs, feelings of helplessness, decision fatigue and 'analysis paralysis', also identified by the interview respondents, when graziers are faced with the complexity of change required. Furthermore, a policy environment which inadvertently creates disincentives for adaptive management was also noted.

Finally, the first round DCAP project also concluded that specialised drought decision support tools were under-utilised, and effective extension services were required for building adaptive capacity in Queensland (QLD) grazing enterprises.

Rationale for the investment

The rationale for this project was to build on DCAP round one findings and help contribute to grazing enterprise resilience and adaptiveness, through a combined social science approach that addressed: a) the need to improve the usefulness and adoption of specialised decision support tools; b) the need to support graziers' decision-making through responsive extension, communication and training; and c) the need to develop drought policy instruments that empower and encourage adaptiveness in ways that are responsive and acceptable to affected communities by better understanding the attitudes, motivations, limitations, needs and values of producers.

3. Project Details & Logical Framework

The project is described in a logical framework in Table 1.

Table 1: Project Logical Framework

Code and Title	DES3: Enabling drought resilience and adoption: A program of social research and knowledge support.
Project Details	Organisation: DES. Period: August 2017 to June 2021. Principal Investigator: Jeanette Durante.
Objectives	1. To engage directly with drought-affected graziers through social research exploring cultural contexts of drought vulnerability, resilience, and socially acceptable changes that can be made through drought extension and policy; 2. To present the results of this research in a draft report for consultation containing recommendations regarding the policy drivers that can best enable the QLD Government, industry, and community to work together to negotiate the 'cultural' transition to drought resilience and adaptiveness; 3. To collaborate with DAF, DES and the University of Southern QLD (USQ) to provide on-going social scientific knowledge and expertise to support the responsive, user-friendly design and implementation of drought-related decision support tools and increase their adoption in targeted groups; 4. Over the four-year life of the project, use scientific knowledge and expertise to manage a tangible contribution to existing and future DAF grazing extension projects and MERI activities across QLD; and 5. Over the four-year life of the project, integrate social science and knowledge into DCAP scientific support, drought policy and coordination activities.
Activities and Outputs	• Re-familiarise with research findings from the DCAP round one project on the social aspects of drought, according to specialist grazing service providers individual and a small number of leading graziers; • Complete a review of the relevant social science literature; • Undertake a media discourse analysis about drought messages (e.g. views, narratives, and expectations) and qualitative interviews with drought affected grazing families; • Assemble information on grazier cultural views (e.g. "is drought a crisis?"), knowledge and attitudes to the 'social licence' under which they operate. Assemble information on disincentives, preparedness, and drought resilience; • Rework decision support tools using information assembled on grazier social attitudes to drought and prepare updated tools that will facilitate improved producer management decisions; • Contribute social research findings to the design of a more effective extension program for drought planning and response; • Identify policy drivers that can best enable government, industry, and community to negotiate the 'cultural' transition to drought resilience and adaptiveness. • Project outputs to date have included: a comprehensive media analysis document; a detailed social science report;; numerous presentations (e.g. webinars, seminars); the creation of numerous social & behavioural insight datasets (e.g. Concepts (Biases, Effects, Heuristics and Fallacies) (>1000 entries); Behaviour Change Interventions and Design Elements (>500 entries); Social psychology concepts (>450 entries); Behavioural

	Insights Books (>200 entries); Behavioural Change Theories & Models (>75 models); TED and TEDx talks (>70 entries); and Mnemonics for Applying Behavioural Insights (7 mnemonics); improved decision support tools (e.g. FORAGE Pasture Growth Alert report, FORAGE Long Term Carrying Capacity report, FORAGE Safe Carrying Capacity report); education materials to support the adoption of decision support tools (e.g. percentile animation); grazing extension support (e.g. social method support for surveys, focus groups and interviews; behaviourally informed communication advice and materials; tailored groups activities and workshops); and evidence-based policy advice for the QLD government.
Outcomes (potential)	• Increased producer understanding and capacity to respond to drought; • Improved decision making on QLD grazing properties; and • Enhanced drought policy, informed by social research.
Impacts (potential)	• Increased productivity and profitability benefits for QLD grazing enterprises (increased net farm income for QLD beef producers); • Contribution to reduced cost to QLD government for drought support; • Decreased damage to land and water resources as a result of more informed drought management decisions. Less environmental damage will help maintain the QLD grazing industry's social licence to operate; • Improved drought management and response skills developed by graziers; • Enhanced drought policy insights developed by researchers and government policy makers; • Increased scientific knowledge and research capacity; and • Contribution to improved regional community wellbeing from spill-over benefits from more productive and profitable grazing enterprises.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment
Table *2* shows the annual investment (cash and in-kind) for the project with funding provided by DAF and in-kind support provided by DSITI.

Table 2: Annual Investment in the Project for Years Ending June 2018 to June 2021 (nominal $)

Contributor	2018	2019	2020	2021	Total
DAF - cash	78,737	78,737	78,737	78,737	**314,948**
DSITI – cash	16,750	16,750	16,750	16,750	**67,000**
DSITI – in-kind	91,143	90,229	73,918	73,918	**329,208**
Total	**186,630**	**185,716**	**169,405**	**169,405**	**711,156**

Source: DES 3 project application calculation spreadsheet, (2017)

Program Management Costs
For the DAF and DES investment, the management and administration costs for the project are already built into the nominal dollar amounts appearing in Table 2.

Real Investment and Extension
For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20-dollar terms using the Implicit GDP Deflator index (ABS, 2020). No other extension costs are envisaged – project findings will be integrated into other DCAP projects and QLD Government policy making.

5. Impacts

An overview of potential impacts in a triple bottom line categorisation is shown in Table 3.

Table 3: Categories of Impacts from the Investment

Economic	Environmental	Social
Increased productivity and profitability benefits for QLD grazing enterprises (increased net farm income for QLD beef producers). Contribution to reduced cost to QLD government for drought support.	Decreased damage to land and water resources as a result of more informed drought management decisions. Less environmental damage will help maintain the QLD grazing industry's social licence to operate.	Improved drought management and response skills developed by graziers. Enhanced drought policy insights developed by researchers and government policy makers. Increased scientific knowledge and research capacity. Contribution to improved regional community wellbeing from spill-over benefits from more productive and profitable grazing enterprises.

Public versus Private Impacts
The impacts identified are both private and public in nature. Private impacts accrue to QLD graziers who enjoy additional productivity and profitability benefits, as a result of improved capacity to respond to drought, combined with maintenance of their social licence to operate. Public impacts include: saved government intervention costs; improved environmental outcomes; capacity building for QLD government research scientists, tool developers and extension staff, and their partners; in addition to graziers themselves, and the community spill-over benefits associated with more productive and profitable grazing enterprises.

Impacts Accruing to other Primary Industries
The general principles developed from this project (e.g. better understanding of beef grazier attitudes to drought and the factors influencing their drought decision making) will also be relevant to other primary industries such as other livestock industries (e.g. sheep, goats), mixed enterprises, broadacre crop production and horticulture.

Distribution of Benefits along the Supply Chain
Some of the potential benefits accruing to QLD graziers will be shared along the supply chain. As a consequence, red meat processors, wholesalers, exporters, retailers, and consumers, will all benefit from investment in this project.

Impacts Overseas
Research results from this project will have limited relevance overseas. Social research activities focus on the Australian situation.

Match with National and State Priorities
The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 4. The investment in

social research and knowledge support is relevant to Rural RD&E Priority 3 and 4 and to Science and Research Priority 1, 2, 7 and 8.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[(a)] (est. 2015)	**Science and Research Priorities[(b)] (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

This investment addressed QLD Science and Research Priorities 1, 3 and 6. In terms of the guides to investment, this investment is likely to have a real future impact on the grazing industry and, through the development and application of decision support tools, is likely to scale toward critical mass.

6. Valuation of Impacts

Impacts not Valued in Monetary Terms
Not all impacts identified in Table 3 could be valued in the assessment. Social impacts were not valued due to the complexity of assigning monetary values to both capacity built and regional spillover benefits.

Impacts Valued in Monetary Terms
Three impacts were valued:

- Increased productivity and profitability on QLD grazing enterprises (increased net farm income for QLD beef producers);
- Contribution to reduced cost to QLD government for drought support; and
- Decreased environmental damage, resulting in the maintenance of the QLD grazing industry's social licence to operate.

Analyses were undertaken for total impacts, including future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty, or for those that were identified as key drivers of investment criteria.

The DES3 project evaluation forms part of a broader assessment of the DCAP Phase 2 investment. Two of the impacts identified above (increased productivity/profitability and decreased risk of a loss of social licence for the QLD grazing industry) were valued at a DCAP Program level. Six DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to these two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

i. Though some benefits from the six contributing projects would accrue to graziers in the NT and the north of Western Australia (WA), the main emphasis of the DCAP projects was in QLD,
ii. The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising 49.8% of the national heard of 22.4 million head (ABS, 2020). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and
iii. The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

Counterfactual
The counterfactual includes a scenario that some social insight would have been gathered through DAF initiatives and activities other than DCAP. Consequently, the assumption is made that it is 50% likely that insights garnered through this project would have been delivered by an alternative means.

A summary of project assumptions and data source is provided in Table 6.

Table 6: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
Impact 1: Increased productivity/profitability on QLD grazing enterprises (increased net farm income for QLD beef producers).		
Baseline data		
Average farm cash income for QLD beef producers.	$163,645 per farm.	5 year average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (ABARES, 2020).
Average number of beef cattle enterprises in QLD	7,069	5 year average based on AgSurf population data for QLD beef (2015 to 2019) (ABARES, 2020). NB: estimate excludes mixed enterprises (beef + sheep).
Current proportion of primary producers in QLD utilising climate forecasting, models, decision support tools etc. for farm decision-making.	40% midpoint of most recent estimate: Cobon et al (2017).	Seasonal climate forecasts are used by 30% to 50% of agricultural producers in decision-making (Keogh et al 2005; Keogh et al 2004a; Australian Government Department of Agriculture Fisheries and Forestry 2004). The uptake of Seasonal Climate Forecasts by agricultural producers in decision-making range from 30% to 50% (Cobon et al 2017).
With Investment in DCAP projects		
Part 1 (existing users): Proportion of existing users (primary producers) of climate forecasting, models, decision support tools who have improved their decision-making specifically due to DCAP Phase 2 investment.	25%	¼ of existing users in QLD, conservative analyst assumption.
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models and decision support tools, etc,.	5%	Conservative estimate based on a minimum profitability/productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al 2000; McKeon et al 2000; Stafford Smith et al 2000; O'Reagain et al 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Part 2 (new users): Proportion QLD producers newly adopting the use of climate forecasting, models, decision support tools etc. to	15% (increasing proportion of total QLD users from 40% to 55%)	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with

improve on-farm decision making.		access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).
Part 2 (new users): Attribution of practice change to DCAP2 investment for new users.	50%	Acknowledges contribution of other drought resilience investments and previous investment in DCAP1.
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
First year of impact.	2020/01	Third year of DCAP investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact.	2024/25	Five years from first year of impact.
Risk factors		
Probability of output.	100%	Outputs have already been delivered.
Probability of outcome.	100%	Already allowed for in the 33% of QLD beef enterprises implementing practice changes on farm.
Probability of impact.	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future.
Impact 2: Contribution to reduced cost to QLD government for drought support.		
Average annual cost of QLD Government drought support.	$27 million/year.	Wade and Burke (2019) estimated at $160 million for the six years 2013 to 2019.
Reduction in drought support costs due to DCAP investment.	10%	Analysts assumption, based on combined impact of DES1 (4%), DES3 (2%), and USQ4 (4%).
First year of reduction.	Year ending June 2022.	Analyst assumption.
Year of maximum reduction.	Year ending June 2026.	Analyst assumption. NB: saving extend from 2026 to the end of the analysis period i.e. 2051.
Risk and attribution factors		
Probability of output.	100%	Analyst assumption.

Probability of outcomes occurring given information generated.	75%	
Probability of impact given outcomes.	75%	
Specific attribution to Project DES3.	1%	
Impact 3: Maintained social licence to operate for some QLD grazing enterprises (QLD beef producers).		
Average annual gross value of production (GVP) of QLD beef cattle.	$5,206.2 million.	5 year average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019).
With Investment in DCAP projects DES1, DES3, USQ4, DAF6, DAF8 and DAF9		
Profit as a proportion of GVP.	10%	Analyst assumption, based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data (2017 to 2019) (Australian Bureau of Agricultural and Resource Economics and Sciences, 2020).
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment.	10%	Analyst assumption.
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment.	1%	Conservative estimate, analyst assumption.
First year of impact.	2020/01	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact.	2024/25	Five years from first year of impact.
Risk factors		
Probability of output.	100%	Outputs have already been delivered.
Probability of outcome.	100%	Already allowed for in the 10% of QLD beef enterprises at risk.
Probability of impact.	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future.
Contribution to relevant DCAP projects from DES3		
Specific attribution to DES3	2.1%	DES3 investment as % of total investment in DES1, DES3, USQ, DAF6, DAF8 and DAF9.

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). Consistent with the CRRDC Cross-RDC Impact Assessment Guidelines (CRRDC 2018), all costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Tables 7 and 8 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 8, has been estimated by multiplying the total PVB by the DAF proportion of real investment (44.3%).

Table 7: Investment Criteria for Total RD&E Investment in DES3

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.05	0.99	2.04	2.86	3.50	4.01	4.40
Present value of costs ($m)	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Net present value ($m)	-0.70	0.25	1.29	2.12	2.76	3.26	3.66
Benefit-cost ratio	0.06	1.33	2.74	3.84	4.70	5.38	5.91
Internal rate of return (IRR) (%)	negative	11.41	21.79	23.87	24.44	24.61	24.67
Modified IRR (%)	negative	8.59	13.17	13.00	12.24	11.48	10.81

Table 8: Investment Criteria for DAF RD&E Investment in DES3

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.02	0.44	0.90	1.27	1.55	1.77	1.95
Present value of costs ($m)	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Net present value ($m)	-0.31	0.11	0.57	0.94	1.22	1.44	1.62
Benefit-cost ratio	0.06	1.33	2.74	3.85	4.71	5.39	5.92
Internal rate of return (IRR) (%)	negative	11.53	21.97	24.05	24.61	24.78	24.84
Modified IRR	negative	8.62	13.19	13.01	12.25	11.49	10.82

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 1.

Figure 1: Annual Cash Flow of Undiscounted Total Net Benefits and Total RD&E Investment Costs

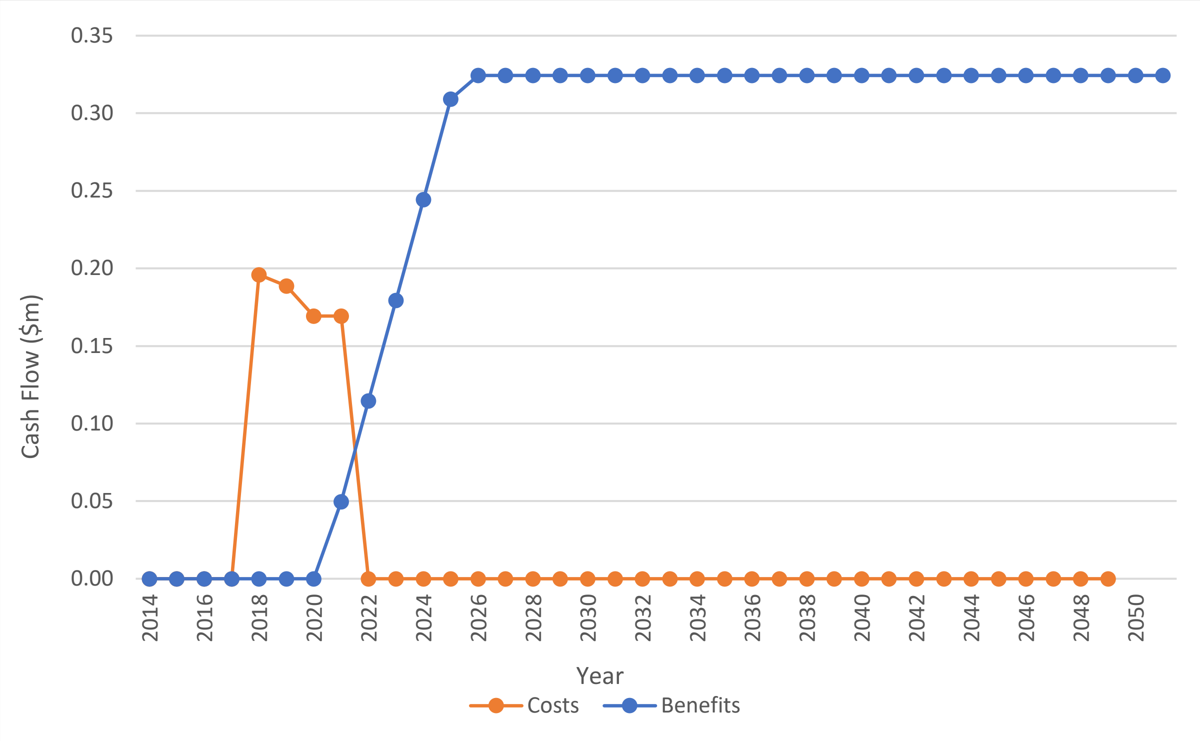

Table 9 shows the contribution of each impact to the total Present Value of Benefits (PVB).

Table 9: Contribution of Benefits

Impact	PVB ($m)	% PVB
Impact 1: Increased productivity/profitability on QLD grazing enterprises (increased net farm income for QLD beef producers)	3.20	75.1
Impact 2: Contribution to reduced cost to QLD government for drought support	0.95	22.2
Impact 3: Maintained social licence to operate for some QLD grazing enterprises (QLD beef producers)	0.12	2.7
Total	**4.26**	**100.0%**

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 10 shows that the investment criteria are moderately sensitive to the discount rate.

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

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	9.33	4.40	2.48
Present value of costs ($m)	0.72	0.75	0.77
Net present value ($m)	8.61	3.66	1.71
Benefit-cost ratio	12.90	5.91	3.23

At the request of DES, a second sensitivity analysis was completed on attribution of QLD beef producer practice change to the DES3 project – Table 11. The sensitivity test shows that halving and doubling the attribution factor makes a relatively small change to overall results.

Table 11: Sensitivity to Attribution of Practice Change to DES3
(Total investment, 30 years)

Investment Criteria	**Attribution of QLD beef producer practice change to DES3**		
	25%	**50% (base)**	**75%**
Present value of benefits ($m)	2.75	4.40	6.05
Present value of costs ($m)	0.75	0.75	0.75
Net present value ($m)	2.01	3.66	5.31
Benefit-cost ratio	3.69	5.91	8.13

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 12). 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 12: Confidence in Analysis of Project

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

Coverage of benefits was assessed as Medium-High. While there were several benefits identified but not valued, the principal economic impacts delivered by the project were quantified (increase in net beef producer income, the protection of the social licence, and the reduced cost of drought to government) and valued.

Confidence in assumptions was rated as Medium as some of the assumptions associated with the increased average income and the reduction in the social licence risk, and the reduction in the government drought costs, were somewhat uncertain.

8. Conclusion

Together with other DCAP projects, the investment in DES3 (social research and knowledge support) has made a positive contribution to the productivity, profitability, and environmental sustainability of the QLD grazing industry. DES3 was funded over the time period 30th June 2018 to 30th June 2021.

The benefits delivered by the project will accrue to QLD graziers (increased profitability, retention of social licence to operate) and the QLD government in the form of saved government drought support.

In summary, the total investment in the project of $0.75 million (present value terms) has been estimated to produce total gross benefits of $4.40 million (present value terms) providing a net present value of $3.66 million, a benefit-cost ratio of 5.91 to 1 (using a 5% discount rate), an internal rate of return of 24.7% and a modified internal rate of return of 10.8%. Impact assessment results can be considered conservative as not all potential benefits were quantified.

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Appendix 4: An Impact Assessment of USQ4: 'Innovative drought and climate variability RD&E to enhance business resilience and build producer capacity to manage climate risk across the northern Australian red meat industry (NACP Phase 2)' (Project USQ4)

Final Report

To

The Department of Agriculture and Fisheries Queensland

by

Agtrans Research
in conjunction with AgEconPlus

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Contents

List of Tables and Figures

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Abbreviations

BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries – Queensland
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
MLA	Meat and Livestock Australia
NPV	Net Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current investment in a project within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP2). The assessment addresses investment in Project USQ4.

The project is described qualitatively using a logical framework that included project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts were then estimated in dollar terms.

Potential benefits were estimated for a range of time frames up to 30 years from the last year of investment in the project (2021/22). Past and future cash flows in 2019/20 dollar terms were discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) was conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

In brief, the investment in NACP Phase Two addresses:

- Research into multi-week, seasonal and longer term forecasting
- Development of targeted decision tools for managing drought to assist producers, as well as policy makers
- Integration of climate forecasting information into existing northern Australia extension and adoption initiatives.

The principal impact identified and valued was improved management decision making by producers in northern Australia leading to increased productivity and profitability of some Queensland pastoral managers. Further impacts delivered and valued were an improved social licence for grazing activities in pastoral Queensland and some contribution to reduced government costs in delivering drought policy and support.

Total funding from all sources over the project duration was approximately $15.91 million (present value terms). Of this total funding, 51% was in cash and 49% was in-kind. Of the in-kind contributions, approximately one third emanated from organisations outside Queensland.

The value of total benefits estimated from the information delivered by the project was estimated at $83.66 million (present value terms). This result generated an estimated net present value of $67.74 million and a benefit-cost ratio of 5.26 to 1.

There were several potential impacts identified that were not valued in monetary terms. These included the benefits from reduced producer income variability, the regional community spillovers from the producer gains emanating from the investment, and the scientific (climate modelling) capability and future capacity built by the investment. Further, the impacts valued for the Queensland beef industry would be a substantial component of all impacts delivered via improved pastoral management as well as via the contribution to social licence maintenance. However, mixed grazing enterprises have not been included nor have the benefits to beef producers in the Northern Territory and the north of Western Australia. The investment criteria reported therefore are likely to have undervalued the full value of benefits delivered by the investment.

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background & Rationale

Background

Phase 1 of the Northern Australia Climate Program (NACP) was undertaken in the year ended June 2017 and addressed the planning of the project undertaken in Phase 2. The NACP included a number of partners including, but not limited to: DCAP (DAF), the Meat Donor Company (MDC) managed by Meat and Livestock Australia (MLA), and the University of Southern Queensland (USQ). The project set out to assist producers in Northern Australia to better manage drought and climate risk.

Previous Project

Phase 1 of NACP identified key reasons why producers were wary of using climate forecasts. Key reasons were:

- A number of regions currently experience low and variable forecast skill,
- There was a low relevance of existing forecast systems and technologies to key management decisions,
- There was a lack of understanding on how to use climate resources and the associated technologies,
- There was a lack of support from climate experts, and
- Proof of value was lacking.

What was Needed

The reasons for the lack of uptake by producers of the forecasts then available were addressed by the funding of NACP Phase 2 via DCAP, including the skill of forecasting in some regions, the type of information produced by forecasts and how such information might be used beneficially by producers in their land management decision making.

3. Project Details

Summary of Investment Details
The investment in NACP Phase 2 refers to the years ending June 2018 to June 2022. USQ was the lead research agency with the base contribution by DCAP and financial contributions from the Bureau of Meteorology (BoM), and the MDC. The DCAP project code, title, Project Leader, Team Personnel and the funding period are summarised in Table 1.

Table 1: Summary Details for the Investment in Phase Two of NACP (USQ4)

Project Code	Title	Project Leader and Team Personnel	Funding Period
USQ4	Innovative drought and climate variability RD&E to enhance business resilience and build producer capacity to manage climate risk across the northern Australian red meat industry.	David Cobon and Chelsea Jarvis, University of Southern Queensland	Years ending June 2018 to June 2022

Logical Framework
Table 2 provides a description of USQ4 in a logical framework format.

Table 2: Logical Framework for USQ4: Innovative Drought and Climate Variability RD&E

Overall Objective	The overall objective of the project is to deliver innovative research, development and extension outcomes to improve the capacity of the red meat industry to manage drought and climate risk across northern Australia.
Specific Objectives	• To improve the basic science and operational skill of seasonal, sub-seasonal (multi-week) and multi-year climate forecasting systems of direct relevance to the Northern Australia red meat industry. • To develop innovative and targeted products for use in drought monitoring, planning and prediction for producers and policy makers. • To integrate and embed climate forecast information into Northern Australia grazing industry networks to improve producer resilience to drought and climate variability.
Activities and Outputs	**Objective 1: Basic science and skill** • Gap analyses regarding influence of key climate/weather systems impacting on Northern Australia climate. • Identification of existing/potential frameworks and data sources, including the developing ACCESS-S forecasting system by BoM. • Work plans and agreements reviewed between USQ, the UK Met Office, and BoM. • Reporting on improvements to BoM's ACCESS-S model for seasonal forecasting that have been due to the Phase 2 NACP funding. • Assessment of value of multi-week /seasonal/decadal/multi-year modelling and predictions including recommendations for operational use and their linkages to pasture modelling systems that could be considered a result of the Phase 2 NACP funding. • Identification and assessment of value of new forecast products due to NACP funding (e.g. quick onset of severe droughts, Madden Julian Oscillation forecasts, wet season onset and breaks, and links to extreme events).

	• Enhancement of spatial drought monitoring and associated management products provided more prominently than currently. • Enhanced data feed for various management applications. **Objective 2: Product development** • Various drought indicators identified and provided online. • A drought monitor product provided on-line. • A monthly targeted climate outlook based on a suite of models, and communicated to extension officers, advisors and producers. • New generation tools and apps developed and provided on-line and via YouTube. The tools and apps are being promoted via extension programs including Grazing BMP, Business Mentoring, Grazing Land Management (GLM Edge) and MLA's Profitable Grazing Systems (PGS) and included managing for climate variability workshops. • Queensland Drought Mitigation Centre (QDMC) online provided drought indices, forecasts and interpretation, onset and length of wet season, and included forecast skill. • Case studies of improved producer decision making regarding drought planning and management, disseminated via networks and workshops. • Demonstration of impacts on forecast skill with use of additional climate variables (temperature etc) in herd modelling with regard to regional pasture growth, liveweight gain, business profit etc, disseminated online at ClimateARM. • Integration of climate management tools and management practices into extension and adoption programs. **Objective 3: Integration of management products and extension** • Delivery of monitoring and communication plans showing various targets across the hierarchy as well as Key Performance Indicators for various activity and outcome measures such as attendances at various workshops (e.g. extent of knowledge and skills gained, practice change etc). • Delivery of climate variability workshops, many of which involved BoM personnel; already 14 climate workshops have been delivered as well as 62 presentations at various workshops and field days, webinars and other extension processes. • Integration of climate risk tools into industry extension programs. • Development of a climate risk communication network for the northern grazing industry. • Development of the Climate Mates program where selected graziers and beef industry leaders have been trained by USQ and extension personnel and then return to their regions to share the increased understanding gained with others. • Development of regional case studies of climate information used in decisions affecting grazing management improvements.
Outcomes	• The basic science and skill activities and outputs of the project are expected to improve the reliability of climate forecasts for some regions in Northern Australia. • These improvements are expected to be very significant for the multi-year forecasts, and significant for the seasonal and multi-week forecasts.

	• Due to the increased coverage and reliability of the climate models, and the extension effort by the project, it has been observed that producer awareness and knowledge of the availability, interpretation and value of climate forecasting and the associated decision aids available has already increased. • This increase is supported by the second DCAP Benchmarking Survey (Coutts, 2019) where it was reported that both awareness and usage of six of eight climate tools nominated in the second survey had increased between the first benchmarking survey in 2017 and the second survey in 2019. In particular, a large increase in awareness and use of the Long Paddock website and Will it Rain booklet were reported. While both surveys were not specific to just beef producers in the north, the comparison is likely to be valid also for beef producers. • It is likely that those producers already using some form of climate based management aids will increase their confidence in using risk-based management decisions and hence improve their decision making due to the information and decision aids produced by the project. * • It is also likely that additional producers (producers who had not previously used climate forecasting aids) will commence using one or more of the climate based management aids promoted by the project investment. • Furthermore, the improved understanding of historical climate patterns and the improvements to climate forecasts (Drought Monitor development) are likely to add value and consistency to local drought committees on drought declarations and on state government policy on drought assistance (e.g. the QLD Drought Relief Assistance Scheme).
Impacts	• Increased average annual productivity and profitability for some Northern Australia pastoral managers from three sources: o new users of seasonal climate forecasting aids o an increase in the value of seasonal forecasting impacts for those decision makers who already use climate forecasting. o decisions by producers before and during a drought made with greater certainty due to the improved multi-year forecasts. • Any productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. • Reduced variability of annual net income for some Northern Australia red meat producers from improved management decision making (e.g. destocking, restocking) that takes into account seasonal and multi-year climate forecasts. • Improved government policy development regarding drought assistance. • Improved environmental management for some Northern Australia beef producers. • Increased scientific and extension capability and capacity. • Reduced personal and community trauma and improved wellbeing. • Maintained social licence for grazing activities in pastoral Queensland. • Impacts of improved climate forecasts to a wider set of businesses and individuals in Northern Australia outside of the red meat industry.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment

Table 3 shows the annual investment in the project by a range of organisations. The large component of external funding in Table 3 should be noted (e.g. 25% of total funding from the Meat Donor Company (MLA) and 14% of total funding from the BOM and UK Met Office).

Table 3: Annual Investment ($) in USQ4 for Years ended June (nominal $)

Contributing Partners	2018	2019	2020	2021	2022	Total
DCAP (Cash)	391,390	481,223	706,098	905,530	536,702	3,020,943
Meat Donor Company (MLA) (Cash)	514,987	633,188	929,076	1,191,487	706,188	3,974,926
USQ (Cash)	123,596	151,965	222,978	285,957	169,485	953,981
USQ (in kind)	1,414,391	1,306,013	1,350,257	1,090,294	0	5,160,955
Bureau of Meteorology (BoM) (in kind) (a)	245,032	250,159	253,128	260,722	0	1,009,041
UK Met Office (in kind) (a)	270,000	275,000	280,000	285,000	0	1,110,000
NT DPIR (in kind)	8,000	8,000	8,000	8,000	2,000	34,000
WA DPIRD (in kind)	8,000	8,000	8,000	8,000	2,000	34,000
Rangelands NRM (WA) (in kind)	34,800	34,800	34,800	34,800	34,800	174,000
Northern Gulf NRM (in kind)	0	0	40,000	40,000	6,000	86,000
TOTAL	3,010,196	3,148,348	3,832,337	4,109,790	1,457,175	15,557,846

(a) BoM and UK Met Office in kind estimates are taken from the project proposal data but the actual in kind is much greater – the value of using their equipment, algorithms, models, scientific IP etc, having direct access to world leading scientists etc is potentially magnitudes greater than estimated here.

Source: David Cobon, USQ, pers comm., 2020

Program Management Costs

For all financial contributions including in-kind, any management and administration costs for the project are assumed already built into the nominal $ amounts appearing in Table 3. An exception is a 12% Meat Donor Company (MDC) administration fee; this was later added to the figures for MDC appearing in Table 3.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20 $ terms using the Implicit Gross Domestic Product Deflator index (ABS, 2020).

5. Impacts

An overview of impacts in a triple bottom line categorisation is shown in Table 4.

Table 4: Preliminary Categories of Impacts from the Investment

Economic	Environmental	Social
Increased average annual productivity and profitability for some Northern Australia red meat producers (QLD, NT, and WA) from at least three sources: • new users of seasonal climate forecasting aids. • an increase in the value of seasonal forecasting impacts for those who already use seasonal climate forecasting. • decisions by producers before and during a drought made with greater certainty due to the improved multi-year forecasts. Any productivity and profitability gains will be shared along the supply chains with transporters, processors, exporters etc. Reduced variability of annual net income for some Northern Australia red meat producers from improved management decision making (e.g. destocking, restocking) that takes into account seasonal and multi-year climate forecasts. Improved government policy development regarding drought assistance. Maintained social licence for the Northern Australia red meat industries. Improved management of businesses in Northern Australia, other than red meat.	Improved environmental management for some Northern Australia red meat producers.	Spillovers to regional communities from increased and less variable incomes for QLD livestock producers and their associated supply chain businesses. Increased scientific and extension capability and capacity. Reduced personal and community trauma and improved wellbeing.

Public versus Private Impacts

The impacts identified from the investment are expected to be predominantly private including red meat producers as well as other businesses in Northern Australia who can benefit from improved seasonal climate forecasts. Some public benefits are likely to be captured by improved policy development by government agencies, improved environmental management by producers, as well as via spillovers to regional communities from red meat producers.

Impacts Overseas

It is unlikely that there will be any significant impacts overseas.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 5. The investment is relevant to Rural RD&E Priorities 1, 3 and 4 and to Science and Research Priorities 1 and 2.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[a] (est. 2015)	**Science and Research Priorities[b] (est. 2016)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2016)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision-making around future investment are reproduced in Table 6.

The investment addressed QLD Science and Research Priority 1,2 and 6. In terms of the guides to investment, the investment is likely to have a real future impact through improved management of red meat producers in Northern Australia. The project was well supported and funded by a range of organisations, many external to the QLD Government and had a distinctive angle as QLD communities will be a major recipient of the impacts.

Table 6: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally-enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

6. Valuation of Impacts

Impacts not Valued in Monetary Terms
The impacts identified but not valued included:

- The impact of reduced income variability was not valued as measures of the current level of income variability were not readily available; furthermore, it is difficult to convert any reduced variability into simple $ terms without knowledge, for example, of interest rates that may apply to surplus investment in good years versus increased loans in poor years.
- The improved management of businesses in Northern Australia other than red meat was not valued due to the difficulty of making credible assumptions on business category and impact levels.
- The increased spillovers to regional communities from sustained or increased income and decreased income variability was not valued as any increased economic activity and employment along the product supply chain would be difficult to value, given the number and spread of production systems, subregions, and the availability of time and resources for valuation.
- The impact of a reduction in environmental damage would be difficult to value given the differences in regional ecosystems, the sometimes localised nature of drought, and the fate of the soil and nutrient losses off-farm. Further elements of this impact are included in the valuation of the maintenance of the social contract.
- Maintained/increased QLD scientific and applied climate forecasting capacity would be difficult to value but some of the new capacity built will be accounted for in the improved climate modelling and tools already developed and valued in the existing analysis.
- The reduced trauma and improved well-being were not valued due to the lack of data on the extent and severity of such impacts and the extent to which they may be reduced by reduced income variability and improved preparedness.

Impacts Valued in Monetary Terms
The three impacts valued in the quantitative analysis are:

- The average annual net economic gain for Queensland beef producers from increased use of improved climate risk assessments and their impact on management decisions.
- Contribution to the maintenance of a social licence for Queensland beef producers.
- Contribution to a more efficient and effective Queensland government drought policy.

The USQ4 project evaluation forms part of a broader assessment of the DCAP Phase 2 investment. Two of the impacts identified above (increased productivity/profitability and decreased risk of a loss of social licence for the QLD grazing industry) were valued at a DCAP Program level. Six DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to these two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

i. Though some benefits from the six contributing projects would accrue to graziers in the NT and the north of Western Australia (WA), the main emphasis of the DCAP projects was in QLD,
ii. The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising 49.8% of the national heard of 22.4 million head (ABS, 2020). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and

iii. The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

It should be noted that the impacts valued for the Queensland beef industry would be a substantial component of all impacts delivered by the improved climate risk management and the contribution to social licence maintenance. However, mixed grazing enterprises have not been included nor have the benefits to beef producers in the Northern Territory and the north of Western Australia.

The third impact identified above for USQ4 has been valued jointly in the quantitative analysis with two other projects including DES3 and DES1.

A summary of all assumptions is presented in Table 7.

Table 7: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
IMPACT 1: Increased profitability/ productivity for QLD beef grazing enterprises (increased net farm income for QLD beef producers)		
Without DCAP Phase 2 Investment		
Average farm cash income for QLD beef producers	$163,645 per farm	5yr average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (ABARES, 2020)
Average number of beef cattle enterprises in QLD	7,069	5yr average based on AgSurf population data for QLD beef (2015 to 2019) (ABARES, 2020)
Current proportion of primary producers in QLD utilising climate forecasting, models, decision support tools etc. for farm decision making	40% Midpoint of most recent estimate: Cobon (2017)	Seasonal climate forecasts are used by 30 to 50% of agricultural producers in decision-making (Keogh et al., 2005; Keogh et al., 2004a; Australian Government Department of Agriculture Fisheries and Forestry, 2004) The uptake of SCF by agricultural producers in decision-making range from 30 to 50% (Cobon et al. 2017)
With DCAP Phase 2 Investment		
Part 1 (existing users): Proportion of existing users (primary producers) of climate forecasting, models, decision support tools who have improved their decision making specifically due to DCAP Phase 2 investment	25%	¼ of existing users in QLD, conservative analyst assumption
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	5%	Conservative estimate based on a minimum profitability/ productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford

		Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2019, Anh Vo et al 2019, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2019).
Part 2 (new users): Proportion QLD beef producers newly adopting the use of climate forecasting, models, decision support tools etc. to improve on-farm decision making	15% (increasing proportion of total QLD users from 40% to 55%)	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).
Part 2 (new users): Attribution of practice change to DCAP2 investment for new users	50%	Acknowledges contribution of other drought resilience investments and previous investment in DCAP1
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2019 , Anh Vo et al 2019 Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2019).
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm
Year of maximum impact	2024/25	Five years from first year of impact
Risk factors		
Probability of output.	100%	Outputs have already been delivered
Probability of outcome	100%	Already allowed for in the 33% of QLD beef enterprises implementing practice changes on farm
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future

Contribution to relevant DCAP projects from USQ4		
Specific attribution to USQ4	45.2%	USQ4 investment as % of total investment in DES1, DES3, USQ4, DAF6, DAF8 and DAF9
IMPACT 2: Maintained social licence to operate for some QLD grazing enterprises (QLD beef producers)		
Baseline data		
Average annual gross value of production (GVP) of QLD beef cattle	$5,206.2 million	5yr average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019)
With investment in DCAP projects DES1, DES3, USQ4, DAF6, DAF8 and DAF9		
Profit as a proportion of GVP	10%	Analyst assumption, based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data 2017 to 2019) (Australian Bureau of Agricultural and Resource Economics and Sciences, 2020)
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment	10%	Analyst assumption
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment	1.0%	Conservative estimate, analyst assumption
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm
Year of maximum impact	2024/25	Five years from first year of impact
Risk factors		
Probability of output	100%	Outputs have already been delivered
Probability of outcome	100%	Already allowed for in the 10% of QLD beef enterprises at risk
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future
Contribution to relevant DCAP projects from USQ4		
Specific attribution to USQ4	45.2%	USQ4 investment as % of total investment in DES1, DES3, USQ4, DAF6, DAF8 and DAF9
IMPACT 3: Contribution to reduced cost to Queensland government for drought support		
Average QLD drought support costs	$27 million per annum	Based on Wade and Burke (2019)
Reduction drought support costs due to DCAP investment	9%	Analyst assumption, based on combined impact of DES1 (4%), DES3 (1%), and USQ4 (4%)
First year of reduction	Year ending June 2022	Analyst assumption

Year of maximum reduction	Year ending June 2026	Analyst assumption
Risk and attribution factors		
Probability of relevant output	100%	Analyst assumptions
Probability of outcomes occurring given information generated	75%	
Probability of impact given outcomes	75%	
Specific attribution to Project USQ4	4%	

Counterfactual

The counterfactual Includes a scenario that some climate knowledge and seasonal forecasting tools would have been utilised by graziers without the investment in USQ4. This scenario is allowed for in the valuation by considering only the improvements in such tools as well as their increased availability and promotion through activities in USQ4 and its associated projects, including delivery projects.

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22).

Investment Criteria

Tables 8 and 9 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 9, has been estimated by multiplying the total PVB by the DAF proportion of real investment (19.3%).

Table 8: Investment Criteria for Total Investment in Project USQ4

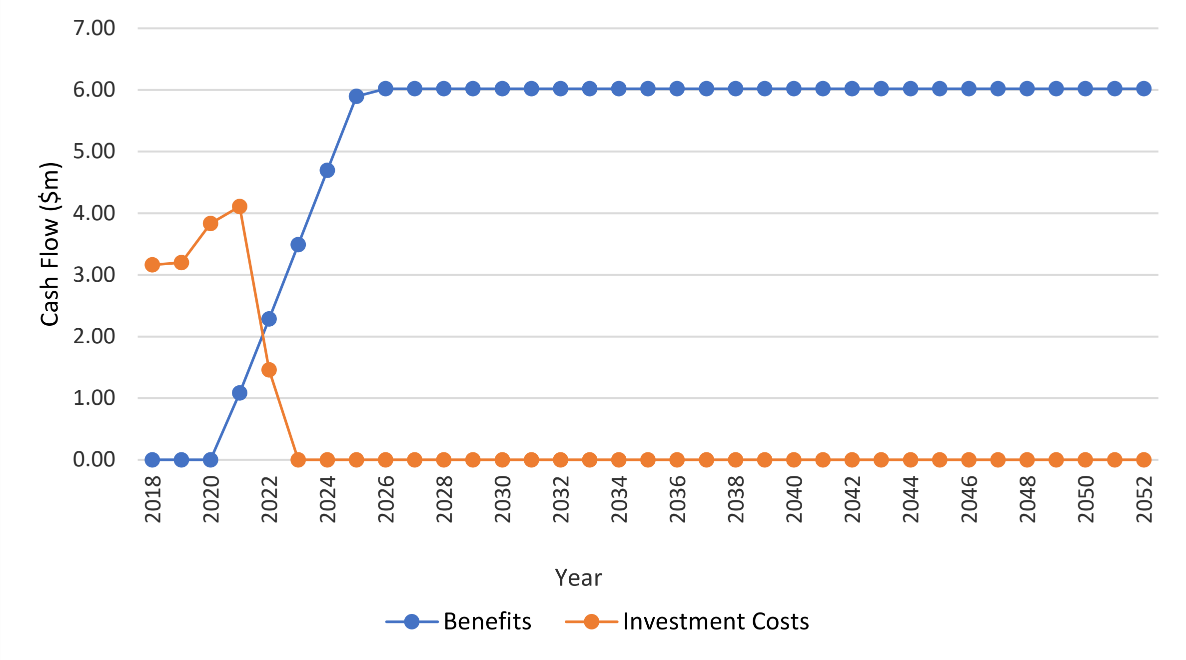
Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	3.10	23.37	41.89	56.40	67.77	76.68	83.66
Present value of costs ($m)	15.91	15.91	15.91	15.91	15.91	15.91	15.91
Net present value ($m)	-12.81	7.46	25.98	40.49	51.86	60.76	67.74
Benefit-cost ratio	0.20	1.47	2.63	3.54	4.26	4.82	5.26
Internal rate of return (IRR) (%)	negative	13.62	21.36	23.08	23.58	23.74	23.79
Modified IRR (%)	negative	14.87	18.55	16.72	14.97	13.59	12.32

Table 9: Investment Criteria for DAF Investment in Project USQ4

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.60	4.52	8.10	10.91	13.11	14.83	16.18
Present value of costs ($m)	3.02	3.02	3.02	3.02	3.02	3.02	3.02
Net present value ($m)	-2.42	1.50	5.08	7.89	10.09	11.81	13.16
Benefit-cost ratio	0.20	1.50	2.68	3.61	4.34	4.91	5.35
Internal rate of return (IRR) (%)	negative	14.84	22.87	24.57	25.03	25.17	25.22
Modified IRR (%)	negative	9.37	15.42	14.59	13.36	12.31	11.29

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

Figure 1: Cash Flow of Undiscounted Total Net Benefits and Total Investment Costs



Source of Benefits

Estimates of the relative contribution of each benefit valued, given the assumptions made, are shown in Table 10. It should be noted that over 87% of the total benefits estimated was derived from producer action taken as a result of improved seasonal and multi-year forecasting produced by USQ4.

Table 10: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Increased beef producer profitability	73.05	87%
Maintenance of social licence	2.63	3%
Reduced cost of QLD Government drought support	7.97	10%
Total	83.66	100%

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 11 presents the results that showed a moderate sensitivity to the discount rate.

Table 11: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	179.96	83.66	46.88
Present value of costs ($m)	15.76	15.91	16.12
Net present value ($m)	164.20	67.74	30.77
Benefit-cost ratio	11.42	5.26	2.91

Other sensitivity analyses including the sensitivity of assumptions for valuing Impacts 1, 2 and 3 are carried out at the Program level due to the valuation frameworks being extended to cover multiple DCAP Phase 2 projects. This was driven by the pathways to impact being common to each of the three impacts.

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 12). 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 12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium	Medium-Low

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

Confidence in assumptions for the valuation also was rated as Medium as several of the assumptions associated with each of the three impacts valued were not well supported by verifiable information.

8. Conclusion

The investment in NACP Phase Two over the years ending June 2018 to June 2022 is likely to be successful and is on track to provide impacts for north Australia red meat producers, the environment and government.

The principal benefits delivered by the project will accrue to beef producers in north Australia from improved on-farm decision making and avoidance of some potential loss in social licence to operate. Some of these benefits are likely to be shared along the product supply chain due to increased economic activity in product transporting and processing. Some public benefits will be delivered via community spillovers from increased, or at least maintained, producer incomes.

The total value of Investment costs included both cash (51%) and in-kind contributions (49%) from a range of organisations. Of the in-kind contributions, approximately one third emanated from organisations outside Queensland.

In summary, the total investment in the project of $15.91 million (present value terms) has been estimated to produce total gross benefits of $83.66 million (present value terms) providing a net present value of $67.74 million, a benefit-cost ratio of 5.26 to 1 (using a 5% discount rate), an internal rate of return of 23.8% and a modified internal rate of return of 12.3%. Using a different approach another study produced a benefit-cost ratio of 7.7 to 1 (Pudmenzky et al, 2017).

The investment criteria reported are likely to have undervalued the full set of impacts delivered by the investment because several impacts identified were not valued in quantitative terms. These included a reduction in producer income variability, benefits to mixed grazing enterprises, benefits to beef producers in the Northern Territory and Western Australia, businesses outside the red meat industry, the spillovers to rural communities, and improvements to scientific and extension capability and capacity.

Also, as with any quantitative impact assessment of an investment that is not yet completed, the investment criteria are based on a number of assumptions that necessarily have to be made, but where supporting data are not available.

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Appendix 5: Impact Assessment of 'Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2' (Project USQ5)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research
in conjunction with AgEconPlus

August 2020

Contents

List of Tables and Figures

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Abbreviations

ABS	Australian Bureau of Statistics
BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries – Queensland
DSITI	Department of Science, Information Technology and Innovation
DCAP	Drought and Climate Adaptation Program
DMF	Discretionary Mutual Fund
GDP	Gross Domestic Product
IRR	Internal Rate of Return
QFF	Queensland Farmers Federation
QLD	Queensland
MERI	Monitoring, Evaluation, Reporting and Improvement
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
NSW	New South Wales
PVB	Present Value of Benefits
PVC	Present Value of Costs
USQ	University of Southern Queensland
WTW	Willis Towers Watson

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current investment in a project within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP2). The current ongoing investment is in Producing Enhanced Crop Insurance Systems and Associated Financial Decision Support Tools - Phase Two (USQ5).

The project is described qualitatively using a logical framework that included project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts were then estimated in dollar terms.

Potential benefits were estimated for a range of time frames up to 30 years from the last year of investment in the project (2020/21). Past and future cash flows in 2019/20 dollar terms were discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) was conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

In brief, the investment in USQ5 is to provide clear recommendations to the agricultural industry, government, and re/insurance companies on how a more liquid and viable market for agricultural insurance products might be established.

Two key impacts were quantified:

- Increased long-term profitability for sugarcane growers adopting the project generated Discretionary Mutual Fund for cyclone risk.
- Contribution to reduced cost to the Queensland Government for disaster recovery Assistance.

The total investment of $2.62 million (present value terms) has been estimated to produce total gross benefits of $10.53 million (present value terms) providing a net present value of $7.91 million, a benefit-cost ratio of 4.0 to 1 (using a 5% discount rate), an internal rate of return of 19.9% and a modified internal rate of return of 9.4%.

The investment criteria reported are likely to have somewhat undervalued the full set of impacts that will be delivered by the investment. This was because a number of the benefits identified were not valued. For reasons explained in the assessment, benefits accruing to income variability, impacts on other industries, farmer mental health, improved development of government policy, capacity built and regional spillovers, were described but not valued.

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background & Rationale

Background
Australian agricultural production is susceptible to a highly variable climate with marked changes in rainfall and temperature around the recorded mean. Australian farmers have limited opportunity for risk offset in their choice of alternative farming systems. The market for farm insurance products is underdeveloped. Multi-peril crop insurance typically does not cover drought – which is the single most problematic risk faced by farmers. Consequently, there was a need to investigate options to establish a liquid and viable market for drought insurance. This project built on a DCAP Phase 1 investigation which developed 'experimental' drought insurance products for the sugarcane and cotton industries.

Rationale for the investment
Crop insurance can assist farmers to manage risks associated with extreme climate and weather events. However, prior research has shown that drought insurance based on the traditional multi-peril model has not been commercially viable. There is a potential role for government to facilitate a robust agricultural insurance market through the provision of data collection, verification and supply systems needed to refine risk models, reduce information asymmetries and, thereby reduce the price of insurance and reinsurance. There may also be a role for government in assisting farmers to become more self-sufficient through the provision of information needed to enhance decision making.

3. Project Details & Logical Framework

The project is described in a logical framework in Table 1.

Table 1: Project Logical Framework

Code and Title	USQ5: Producing enhanced crop insurance systems and associated financial decision support tools – Phase 2.
Project Details	Organisation: University of Southern Queensland (USQ). Period: October 2017 to September 2021. Principal Investigator: Shahbaz Mushtaq.
Objectives	The objective of this project was to provide clear recommendations to the agricultural industry, government, and re/insurance companies on how a more liquid and viable market for agricultural insurance products might be established, including to: 1. Investigate alternative innovative options for roll out of cost-effective market ready products (products developed in Phase 1) 2. Examine the financial viability and acceptance of developed insurance products for important agricultural and supply chain industries 3. Assist in decision making by developing user-friendly decision support tools.
Activities and Outputs	• Test financial viability (willingness to pay) of ‘experimental’ insurance products developed in Phase 1 of the project with the sugarcane and cotton industries. Determine if cost-effective and viable products can be delivered over multiple years. • Prepare case studies that show the financial viability of crop insurance products at different premium levels. • Expand project coverage to additional crops (macadamia, sweet corn, lettuce, and wheat) and develop ‘experimental’ insurance product that address an assessment of climate risks, crop modelling, stakeholder risk perceptions, attitudes, and willingness to pay. • Develop innovative methods such as new pathways to market to encourage producer use of experimental products e.g. Discretionary Mutual Funds (DMFs). • Assess the potential of alternative mechanisms for managing drought and climate risk e.g. government support for the pricing of insurance products and use of industry levies to underwrite insurance premiums. • Develop a prototype decision support tool for use by producers to inform the choice of insurance products. • The products developed by the project were pricing tools for drought, excess rain, cyclone and a DMF (risk sharing structure, with no binding legal obligation to provide payouts). • Sugarcane products addressed drought, excess harvest, and cyclone. • Cotton products all addressed various aspects of drought. • Macadamia products focussed on drought, heat days, and tropical cyclone. • Horticulture (sweet corn, lettuce) products were for heat days. • Broadacre (wheat) products were developed for drought. • The DMF model illustrated how a cyclone risk management product can be delivered over multiple years with retention and capitalisation of the members’ funds, particularly in the early years. Based on historical cyclone data and anticipated take-up numbers, global insurers have indicated their willingness to commit to this product over the long term.

	• A DMF for sugarcane cyclone risk has the best chance of becoming a commercial product as a result of USQ5 research.
Outcomes (potential)	• Potential for cost effective, viable and sustainable crop insurance products. • The potential for increased use of crop insurance by producers. • The potential for a reduction in extreme whether/climate event related loss, and an increase in long-term profitability, for primary producers using project generated crop insurance products.
Impacts (potential)	• Economic – increased long-term profitability for sugarcane growers adopting the project generated DMF for cyclone risk. A DMF for sugarcane cyclone risk was the most well developed product originating from USQ5. • Economic – reduced income variability and increased investment confidence for sugarcane growers adopting the project generated DMF for cyclone risk. • Economic – longer term potential for improved profitability and reduced income variability for other primary producers adopting potential USQ5 products – i.e. growers of cotton, macadamia, sweet corn, lettuce and wheat. • Economic – contribution to reduced cost to QLD government for disaster recovery assistance. • Economic – improved development of government policy with additional climate risk insight. • Capacity – additional understanding of weather and climatic risk, financial risk management using insurance by researchers and primary producers • Capacity – the training of a PhD student in agricultural risk management / financial instruments. • Social – potential positive mental health impacts for individual farmers, possibly even suicide prevention. • Social – contribution to improved regional community wellbeing from spill-over benefits from a more profitable and stable Australian crop sector.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment
Table 2 shows the annual investment (cash and in-kind) for the project with funding provided by USQ, Willis Towers Watson (WTW), Queensland Farmers Federation (QFF).

Table 2: Annual Investment in the Project for Years Ending June 2018 to June 2021 (nominal $)

Contributor	2018	2019	2020	2021	Total
DAF - cash	270,000	270,000	270,000	270,000	1,080,000
USQ - in-kind	142,000	142,000	142,000	142,000	568,000
WTW - in-kind	170,000	170,000	170,000	170,000	680,000
QFF - in-kind	45,000	45,000	45,000	45,000	180,000
	627,000	627,000	627,000	627,000	2,508,000

Source: final contract. NB: Willis Towers Watson is an international risk management and insurance brokerage firm

Program Management Costs
For the DAF, USQ, WTW and QFF investment, the management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table *2*.

Real Investment and Extension
For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20 dollar terms using the Implicit GDP Deflator index (ABS, 2020). Extension will be required to achieve sugarcane industry take up and a critical mass of participants necessary for a viable Discretionary Mutual Fund.

5. Impacts

An overview of potential impacts in a triple bottom line categorisation is shown in Table 3.

Table 3: Categories of Impacts from the Investment

Economic	Environmental	Social
Increased long-term profitability for sugarcane growers adopting the project generated DMF for cyclone risk. Reduced income variability and increased investment confidence for sugarcane growers adopting the project generated DMF for cyclone risk. Longer term potential for improved profitability and reduced income variability for other primary producers adopting potential USQ5 products i.e. growers of cotton, macadamia, sweet corn, lettuce, and wheat. Contribution to reduced cost to QLD government for disaster recovery assistance. Improved development of government policy with additional climate risk insight.	Nil.	Improved community well-being: potential positive mental health impacts for individual farmers, possibly even suicide prevention. Additional understanding of weather and climatic risk, financial risk management using insurance by researchers and primary producers. The training of a PhD student in agricultural risk management / financial instruments. Contribution to improved regional community wellbeing from spill-over benefits from a more profitable and stable Australian crop sector.

Public versus Private Impacts
The impacts identified from the investment are mostly private in nature. Private impacts accrue to crop growers, especially sugarcane growers, making use of commercially viable insurance products. Public impacts include saved government intervention costs, capacity built in the research sector and community spill-over benefits associated with a more profitable and stable Australian crop sector.

Impacts Accruing to other Primary Industries
The project has investigated enhanced crop insurance systems and financial decision support tools for sugarcane, cotton, macadamia, sweet corn, lettuce and wheat. Crop risks and principles developed are also likely to be relevant to a wider gambit of horticulture and broadacre crops including annual crops, tree crops, cereals and coarse grains.

Distribution of Benefits along the Supply Chain
Some of the potential benefits accruing to sugarcane growers in the form of increased profitability will be shared along the supply chain including sugarcane processing businesses.

Impacts Overseas
Project partner Willis Towers Watson is an international risk management and insurance brokerage firm. Principles and products developed as part of this project are likely to have application in other, overseas agricultural risk management markets.

Match with National and State Priorities
The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 4. The investment in enhanced crop insurance systems and associated financial decision support tools is relevant to Science and Research Priority 1 and 7.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[(a)] (est. 2015)	**Science and Research Priorities[(b)] (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally-enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

The investment addressed QLD Science and Research Priority 1. In terms of the guides to investment, the investment is likely to have a real future impact on the profitability of crop production. It has achieved external commitment via a major insurance/reinsurance company (Willis) and the QFF. It has a distinctive angle – addressing market failure and providing a catalyst for additional, commercially viable insurance products. The DMF for cyclone risk is likely to scale toward critical mass for sugarcane growers.

6. Valuation of Impacts

Impacts Valued in Monetary Terms
Analyses were undertaken for total impacts that included future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of investment criteria.

Two key impacts have been quantified:

- Increased long-term profitability for sugarcane growers adopting the project generated DMF for cyclone risk.
- Contribution to Reduced Cost to QLD Government for Disaster Recovery Assistance.

Impacts not Valued in Monetary Terms
Not all impacts identified in Table 3 have been valued in the assessment. Reduced income variability/increased investment confidence for sugarcane growers adopting DMF for cyclone risk was not quantified due to difficulty in developing a framework that would not 'double count' the profit increase impact.

Longer term potential for improved profitability and reduced income variability for other primary industries (cotton, macadamia, sweet corn, lettuce, and wheat) was not valued due to a lack of supporting evidence at this point in time. The analyst notes that a cotton risk assessment and premium estimator tool has been advanced over the course of this impact assessment but as of March 2020 (DCAP insurance project milestone 10 drought DSS for cotton), it is yet to be reviewed by growers, consultants, or industry experts.

Improved development of government policy with additional climate risk insight as a result of USQ5 has not been quantified as the link between project generated data and savings associated with policy development was not yet apparent.

Improved farmer mental health also lacked evidence that would allow quantification. The complexity of assigning monetary values to the impact of research capacity built and increased regional income prevented quantification of these potential benefits in this analysis.

Valuation of Impact 1: Increased Long-term Profitability for Canegrowers Adopting a DMF for Cyclone Risk
A DMF to manage cyclone risk for sugarcane growers, together with project generated financial decision support tools, will allow adopting canegrowers to offset some of the loss associated with an extreme weather event. Over time, this form of crop insurance will reduce the financial impact of cyclones and make a positive contribution to increased canegrower profit. The value of seasonal risk mitigation was estimated for canegrowers at between $0 and $347/ha/year by the NSW Department of Primary Industries (Darbyshire et al, 2018). The mid-point of this estimate has been used for valuation of impact. This is a gross benefit which needs to be offset by the cost of DMF contributions.

Communication of project progress and the potential for offsetting the risk of cyclone loss in the sugarcane industry has been underway. Coutts (2020) notes that sugarcane growers have been targeted through CANEGROWERS magazine Policy Update column (3,500 circulation); and awareness raising through USQ presentations to industry and government.

Valuation of Impact 2: Contribution to Reduced Cost to QLD Government for Disaster Recovery Assistance

Growers adopting project generated enhanced crop insurance systems and associated financial decision support tools are less likely to require financial assistance from the QLD Government as a result of drought, cyclone, or an extreme rainfall event. Cyclones occur at regular intervals in QLD sugarcane growing areas, for example Cyclone 'Debbie' 2017, Cyclone 'Oswald' 2014, and Cyclone 'Yasi' 2011. Following Cyclone 'Debbie', the QLD Government made concessional loans, working capital loans and freight subsidies available to cyclone affected sugarcane growers. Some of these costs will become cost savings as a result of USQ5.

Attribution

Project impacts rely the current DCAP Phase 2 project (USQ5), a DCAP Phase 1 insurance project valued at $290,000, post project extension and insurance company investment in product development and marketing. After consideration of these contributing investments an attribution factor of 35% has been assumed for USQ5.

Counterfactual

In the absence of USQ5, the assumption is made that it is 50% likely another research project would have addressed the USQ5 objectives and have made progress developing cyclone risk mitigation products for sugarcane growers.

A summary of project assumptions and data source is provided in Table 6.

Table 6: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
Impact 1: Increased Long-term Profitability for Canegrowers Adopting a DMF for Cyclone Risk		
Long-term average increase in sugarcane growing profitability with cyclone insurance in place.	$0 to $347/ha/year (mid-point of $173.50/ha assumed)	Sugar Case Study – seasonal risk mitigation in Australian agriculture (Darbyshire, et at 2108) https://www.dpi.nsw.gov.au/climate-and-emergencies/climate-and-weather/research/value-of-forecasts
Cost of insurance premiums/contribution to DMF	$20/ha/year	Consultant estimate – annual contributions of $2,800 to DMF for average area of production per farm of 140 ha. This assumption was subject to sensitivity analysis at $10 and $40/ha/year.
Gain in long term average profit from adopting cyclone risk insurance.	153.50/ha	$173.50/ha less $20/ha.
Average area of production per farm.	140 ha	USQ DCAP Phase 2 Producing Enhanced Crop Insurance Systems Case Study.
Year in which a commercial DMF for cyclone risk for sugarcane growers first adopted.	2023	Two years after project completion and allowing for extension and insurance company investment in product development and marketing.

Maximum number of QLD sugarcane growers using project outputs.	1,000	Consultant estimate. Peak industry body Canegrowers report that there are approximately 4,000 Australian growers.
Impact 2: Contribution to Reduced Cost to QLD Government for Disaster Recovery Assistance		
Cost to the QLD Government of providing cyclone relief to sugarcane growers.	$15,000 per farm.	Following Cyclone 'Debbie' in 2017 the QLD Government made concessional loans, working capital loans and freight subsidies available to eligible sugarcane growers. The cost of loan capital is assessed by the consultant at $10,000 per eligible canegrower plus $5,000 for freight assistance.
Frequency of cyclone events.	33% (1 in 3 years)	Consultant estimate based on recent history – Cyclone 'Debbie' 2017, Cyclone 'Oswald' 2014, and Cyclone 'Yasi' 2011.
Year in which a commercial DMF for cyclone risk for sugarcane growers first adopted.	2023	Two years after project completion and allowing for extension and insurance company investment in product development and marketing.
Maximum number of QLD sugarcane growers using project outputs.	1,000	Consultant estimate. Peak industry body Canegrowers report that there are approximately 4,000 Australian growers.
Year of maximum adoption of DMFs for cyclone risk.	2028	Consultant estimate assuming a 'ramp up' of adoption as canegrowers become more aware of the benefits of the DMF.
Period of maximum impact.	6 years (to 2033) decreasing linearly to zero by 2039 (see below)	Consultant estimate. The DMF has a 'life cycle' which includes a 'ramp up' and a 'ramp down' of use by canegrowers. 'Ramp down' associated with switch to replacement product(s).
Assumptions common to valuation of both impacts		
Year in which project outputs (DMF for cyclone risk for sugarcane growers and decision support systems) are replaced with superior products.	2039	Consultant estimate.
Attribution of impacts to this project (USQ5).	35%.	Impact valued is due to both prior and subsequent investments.
Probability of output.	70%	Consultant estimate – the remains some uncertainty about the project generated DMF and associated financial decision support tool.

Probability of impact	70%	Consultant estimate – products may be too complex for use by producers and advisors - sophisticated financial instruments do not have appeal to all primary producers.
Counterfactual.	50%.	In the absence of USQ5 the assumption is made that it is 50% likely that another research project would have made progress developing cyclone risk mitigation products.

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Tables 7 and 8 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 8, has been estimated by multiplying the total PVB by the DAF proportion of real investment (43.1%).

Table 7: Investment Criteria for Total RD&E Investment in USQ5

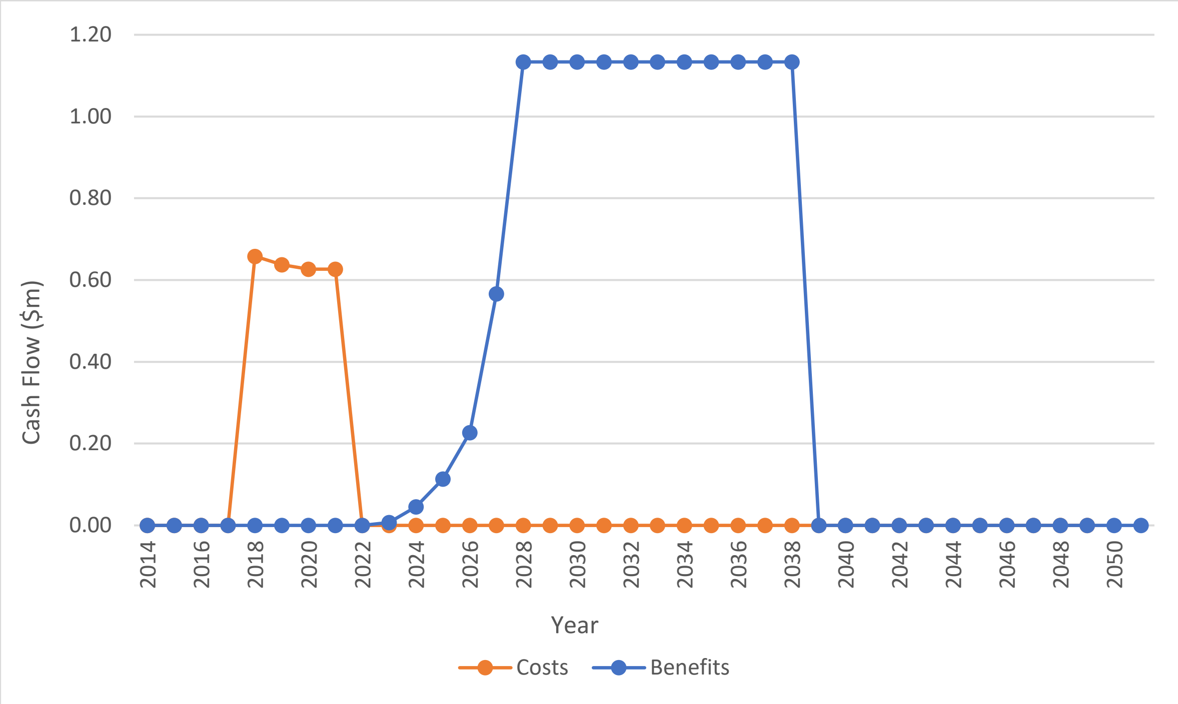
Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.60	7.12	10.48	10.53	10.53	10.53
Present value of costs ($m)	2.62	2.62	2.62	2.62	2.62	2.62	2.62
Net present value ($m)	-2.62	-2.02	4.50	7.86	7.91	7.91	7.91
Benefit-cost ratio	0.00	0.23	2.72	4.00	4.02	4.02	4.02
Internal rate of return (IRR) (%)	negative	negative	16.90	19.93	19.95	19.95	19.95
Modified IRR (%)	negative	negative	12.78	12.95	11.27	10.16	9.38

Table 8: Investment Criteria for DAF RD&E Investment in USQ5

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.00	0.26	3.07	4.51	4.53	4.53	4.53
Present value of costs ($m)	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Net present value ($m)	-1.13	-0.87	1.94	3.39	3.40	3.40	3.40
Benefit-cost ratio	0.00	0.23	2.72	4.00	4.02	4.02	4.02
Internal rate of return (IRR) (%)	negative	negative	16.90	19.93	19.95	19.95	19.95
Modified IRR	negative	negative	12.78	12.95	11.27	10.16	9.38

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 1.

Figure 1: Annual Cash Flow of Undiscounted Total Net Benefits and Total RD&E Investment Costs



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

Table 9: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Increased Long-term Profitability for Canegrowers Adopting a DMF for Cyclone Risk	8.56	81.3
Contribution to Reduced Cost to QLD Government for Disaster Recovery Assistance	1.97	18.7
Total	10.53	100.0

Sensitivity Analyses
A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 10 shows that investment criteria are only moderately sensitive to the discount rate.

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

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	17.44	10.53	6.59
Present value of costs ($m)	2.55	2.62	2.69
Net present value ($m)	14.89	7.91	3.90
Benefit-cost ratio	6.84	4.02	2.45

A sensitivity analysis was completed on the cost of insurance premiums/contributions to the DMF (Table 11). Results show that even with doubling the cost of insurance, returns from the investment remain positive.

Table 11: Sensitivity to Cost of Insurance/DMF Contributions
(Total investment, 30 years)

Investment Criteria	**Annual Cost of Insurance/DMF Contributions**		
	$10/ha	**$20/ha (base)**	**$40/ha**
Present value of benefits ($m)	11.08	10.53	9.41
Present value of costs ($m)	2.62	2.62	2.62
Net present value ($m)	8.46	7.91	6.79
Benefit-cost ratio	4.23	4.02	3.59

A final sensitivity analysis was completed on the number of canegrowers adopting cyclone insurance (Table 12). Results show that even if halve the assumed number of canegrowers adopt the DMF, then investment costs will exceed investment benefits.

Table 12: Sensitivity to Number of Canegrowers Adopting Insurance/DMF Contributions
(Total investment, 30 years)

Investment Criteria	**Maximum Number of Canegrowers Adopting Cyclone Risk Insurance**		
	500	**1,000 (base)**	**2,000**
Present value of benefits ($m)	5.26	10.53	21.05
Present value of costs ($m)	2.62	2.62	2.62
Net present value ($m)	2.64	7.91	18.43
Benefit-cost ratio	2.01	4.02	8.04

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 13). The rating categories used are High, Medium, and Low, where:

- High: denotes a good coverage of benefits or reasonable confidence in the assumptions made
- Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
- Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 13: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

Coverage of benefits was assessed as medium. While a key economic benefit was quantified, other potential economic and social/public benefits were not.

Confidence in assumptions was rated as medium. While most assumptions applied in valuing impacts were drawn from credible sources a number of assumptions needed to be made by the analyst.

8. Conclusion

Investment in this project has made significant progress toward the establishment of a commercial insurance product for sugarcane growers to manage the risk of cyclone damage. Additional benefits for other industries are also possible.

In summary, the total investment in the project has produced a number of impacts and some of the key benefits have been valued. The total investment of $2.62 million (present value terms) has been estimated to produce total gross benefits of $10.53 million (present value terms) providing a net present value of $7.91 million, a benefit-cost ratio of 4.0 to 1 (using a 5% discount rate), an internal rate of return of 19.9% and a modified internal rate of return of 9.4%.

The investment criteria reported are likely to have somewhat undervalued the full set of impacts that will be delivered by the investment. This was because a number of the benefits identified were not valued. For reasons explained in the assessment, benefits accruing to income variability, impacts on other industries, farmer mental health, improved development of government policy, capacity built and regional spillovers, were described but not valued.

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Appendix 6: An Impact Assessment of ‘Delivering Integrated Production and Economic Knowledge and Skills to Improve Drought Management Outcomes for Grazing Enterprises’ (Project DAF6)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research

in conjunction with AgEconPlus

August 2020

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List of Tables and Figures

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Abbreviations

ABS	Australian Bureau of Statistics
BCD	Breedcow and Dynama
BCR	Benefit-Cost Ratio
BMP	Best Management Practice
BoM	Bureau of Meteorology
CQ	Central Queensland
CRRDC	Council of Rural Research and Development Corporations
CWMG	Central West Mitchell Grasslands
DAF	Department of Agriculture and Fisheries (Queensland)
DCAP	Drought and Climate Adaptation Program
DES	Department of Environment and Science (Queensland)
DPIRD	Department of Primary Industries and Regional Development (Western Australia)
DST	Decision Support Tool
GDP	Gross Domestic Product
GFNGN	GrazingFutures Northern Grazing Network
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
MLA	Meat and Livestock Australia
NPV	Net Present Value
NRM	Natural Resource Management
NT	Northern Territory
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
RFDS	Royal Flying Doctor Service
SCF	Seasonal Climate Forecasting
USQ	University of Southern Queensland
WA	Western Australia

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a Queensland Department of Agriculture and Fisheries (DAF) investment in a project known as *DAF6: Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises*. The project was one of a suite of projects funded under the second iteration of DAF's Drought and Climate Adaptation Program (DCAP). The DCAP project DAF6 was funded by DAF for the years ended 30 June 2018 to 2020.

The project was first analysed qualitatively using a logical framework approach that included a description of project objectives, activities and outputs, and actual and potential outcomes and impacts. Impacts were categorised into a triple bottom line framework. Principal impacts were then valued.

Benefits were estimated for a range of time frames up to 30 years from the last year of investment in the project (2019/20). Past and future cash flows in 2019/20 dollar terms were discounted to the year 2019/20 (year of analysis) using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis was conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The major impacts identified were economic/financial in nature. However, some social and environmental impacts also were identified but not valued. It is expected that Queensland (QLD) graziers will be the major beneficiaries. Impacts include increased average annual net farm income for QLD beef producers, potentially improved environmental outcomes, maintained social licence to operate, increased industry resilience, and increased regional community wellbeing.

The total investment in the project of $1.33 million (present value terms) has been estimated to produce total gross benefits of $6.22 million (present value terms) providing a net present value of $4.89 million, a benefit-cost ratio of 4.67 to 1 (using a 5% discount rate over 30 years), an internal rate of return of 20.5% and a modified internal rate of return of 7.7%. Despite the fact that the present value of costs may have been underestimated since some potential costs were not able to be included in the analysis (e.g. costs associated with non-DAF personnel attending DCAP DAF6 events/activities), based on the conservative assumptions made and the fact that a number of benefits were identified but not valued, the investment criteria reported are likely to be an underestimate of the true performance of the DAF6 investment as several impacts identified were not valued in monetary terms.

1. Evaluation Methods

The evaluation approach 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. This impact assessment uses cost-benefit analysis as its principal tool. The approach includes both qualitative and quantitative analyses that are in accord with the current evaluation guidelines of the Council of Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, and potential and actual outcomes and impacts. The principal economic, environmental and social impacts are then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, the difficulty in defining the pathway to impact (linking the impact to the original investment), or the likely low relative significance of the impact compared to those that were valued. The impacts valued therefore are deemed to represent the principal benefits delivered by the project.

2. Background & Rationale

Background

The Drought and Climate Adaptation Program

The Drought and Climate Adaptation Program (DCAP) is an initiative lead by the Queensland Department of Agriculture and Fisheries (DAF) that aims to help Australian producers better manage drought and climate impacts through research that will help manage financial risks and decision making around droughts and climate variability through improved forecast products, tools and extension activities (Queensland Government, 2020).

DCAP commenced with Phase One in 2015/16. Phase One ended June 2017 and the Program is now in Phase Two that will run to June 2021 and consists of nine integrated research, development and extension (RD&E) investments (Coutts J&R, 2019). DCAP's major funding partners include DAF, the Department of Environment and Sciences (DES), the University of Southern Queensland (USQ), the Bureau of Meteorology (BoM), and Meat and Livestock Australia (MLA).

DCAP and the Grazing Industry

Managing climate variability and drought is a significant challenge for the Australian grazing industry. Despite programs and resources (such as the Grazing Best Management Practice (BMP) guidelines), evidence suggests that many grazing enterprises in Queensland (QLD) and northern Australia fail to effectively manage climate variability and improve their capability to prepare for future drought cycles (McCartney, 2017). McCartney (2017) identified a number of factors that may limit decision making for drought preparedness and management in QLD grazing enterprises. Factors included:

- A grazier's financial and economic situation,
- The nature of grazing production systems,
- The management focus of a grazier such as record keeping, planning and decision-making systems,
- Graziers' knowledge, willingness and capacity to learn and change,
- Graziers' personal attitudes and circumstances, and
- The role of Government.

The 2017 report also identified a number of future opportunities to address key limitations and improve management and decision making for drought and climate variability for QLD grazing businesses. Future opportunities were grouped into six categories as follows (McCartney, 2017):

1. Increase extension services and other independent service providers,
2. Develop decision support services, tools and aids,
3. Reform drought assistance arrangements,
4. Support drought-related research and development,
5. Challenge industry and community attitudes to drought, and
6. Promote industry diversification and off farm investment.

A number of DCAP project investments have been targeted at addressing such opportunities and improving drought preparedness and climate adaptation for grazing businesses in QLD and northern Australia.

Rationale for the Current Investment

Long term grazing trials in QLD and other pasture research have identified guidelines for long-term safe/sustainable livestock carrying capacity. However, there is widespread evidence that producers are stocking perennial pastures at significantly higher rates than the guidelines provided by research and government agencies. This suggests that there is a disconnect between the recommendations of research and the stocking rate decisions applied by many managers of grazing enterprises.

The DCAP (Phase 2) project titled '*DAF6: Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises'* (hereafter referred to as DAF6) was funded to improve the knowledge and skills of advisors and graziers in assessing the economic implications of management decisions that can be applied to prepare for, respond to, or recover from, drought.

DAF6 contributes to DCAP's project specific research and development (R&D) activities and outputs, and to DCAP's integrated, cross-project adoption activities.

3. Project Details & Logical Framework

Summary of Projects

DCAP Project Code	**Project Title**	**Project Leader**	**Funding Period**
DAF6	Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises	Maree Bowen, Principal Research Scientist, Ruminant Nutrition, Animal Science, DAF	July 2018 to December 2020

Logical Framework

Table 1 provides a description of the project using a logical framework approach.

Table 1: Logical Framework for DCAP Project DAF6

Objectives	Specific objectives are that the project will deliver: 1. Seven regional reports (i.e. one for each study region) summarising: a. the synthesis of scientific knowledge on the effect of management strategies designed to prepare, respond and recover from drought, and b. accompanying scenario analysis to examine the economic implications of each of these strategies. 2. Modified property level, regionally specific, herd and business models, incorporating spreadsheets and decision support framework that can be used by consultants and advisors to assist producers to assess their own scenarios. These tools will be made available for download on appropriate web pages including QDMC and FutureBeef platforms 3. Fact sheets and web pages designed for producers, providing a framework for decision making and summarising expected whole-farm impact on production and profit of key management strategies. 4. Trained extension and technical staff from within DAF and Natural Resource Management (NRM) groups, as well as private consultants, in the use of the decision support tools (DSTs) and framework. 5. Delivery of at least 7 workshops to producers with one workshop in each target region. These workshops may be undertaken as a component of an existing workshop planned by DAF staff where this better suits regional staff. 6. A report detailing the extension and training activities conducted during the project, including feedback from: a. advisors and extension officers engaged in the training activities, and b. producers participating in the workshops. 7. A final project report synthesising learnings and recommendations from the project and which can be used to inform future investment and policy in this area. 8. At least one journal publication submitted to Animal Production Science (CSIRO publishing).
Activities	**Component 1:** Synthesis of scientific knowledge • Existing knowledge on the effect of management strategies (designed to prepare, respond and recover from drought) on pasture resilience

	and quality, animal nutrition and productivity will be reviewed and synthesised. The synthesis will include strategies that: i) Build resilience prior to drought by building profitable and resilient grazing systems and will consider the impact of: a) grazing pressure on long-term sustainability and profitability, and b) the inclusion of perennial legumes in perennial pasture systems, where appropriate, and their optimal management. ii) Respond to drought, including the likely responses to: a) alternative drought/supplement feeding strategies, and b) de-stocking. iii) Enable drought recovery, including: a) alternative ways to utilise the existing feedbase and nutrition available during the recovery period to rebuild the herd/flock. • The 'preparing for drought' sections of each report focus on identifying strategies that can improve profitability and hence the resilience of grazing businesses (Maree Bowen, pers. comm., 2020). • Grazing pressure and long-term sustainability were looked at specifically in the Northern Gulf and Central West Mitchell Grasslands (CWMG) whereas the inclusion and management of perennial legumes has been investigated for the Fitzroy and Northern Gulf regions (Maree Bowen, pers. comm., 2020). • Further, examples of how to use suitable and freely available spreadsheet tools/models to examine drought response and recovery aspects (e.g. destocking and then restocking) have been included in the Fitzroy, Northern Gulf and CWMG reports. Nine drought response and recovery presentations with accompanying spreadsheet examples also were recorded and now are available for download on the project website (Maree Bowen, pers. comm., 2020). • The GRASP pasture growth model[1] will be used to provide native and buffel pasture growth estimates for carrying capacity calculations. • Where applicable, management scenarios will be improved or extended by using the GRASP model to simulate degradation and recovery of native pastures and by linking with an MLA co-funded Indian couch project that may indicate productivity of couch pastures. • Estimation of the impact of buffel rundown on productivity may be possible following investigation of the outcomes of the MLA Pasture Rundown project. • The project also has links other DCAP projects including DAF8 (GrazingFutures) and DES1 (Inside Edge) as well as to other non-DCAP funded DAF extension teams and projects (Maree Bowen, pers. comm., 2020). **Component 2:** Application of the knowledge • A suite of example scenarios (property level, regionally relevant herd/flock models and case studies) will be developed that can be used as a template to inform decision making. • The example scenarios will be developed in consultation with regional DAF staff and local producers.

[1] The simulation model GRASP is a soil-water, pasture-growth model developed for northern Australia and rangeland pastures. For more information see: https://www.mla.com.au/CustomControls/PaymentGateway/ViewFile.aspx?YH/fvAKp4RpNl9sdoI667NEtmta+JIyTKc1mjpcaaAXjrelkZSKwQbqJd2NmyI/43EYMKKAfsht7d1Tnt3BqiA==

	• The scenarios will extend the options already developed in the 'Enterprise Improvement' document (Chudleigh, Oxley, & Bowen, 2019) to include drought preparation, response and recovery scenarios. • Existing forecasting tools and the concept of critical decision points will be incorporated in the development of the models and examples. • The analyses will be developed for seven regions across QLD including: i) Norther Gulf (Georgetown – beef) ii) Northern Downs (Hughenden/Richmond – beef) iii) Mitchell Grasslands (Longreach/Winton – sheep and beef) iv) Mulga Lands (Charleville – sheep and beef) v) Fitzroy (Emerald – beef) vi) Rangelands (sheep and goats) • The Fitzroy report was submitted on 26/04/2018 and the Northern Gulf report was submitted on 30/07/2018. The third regional report for the Central West Mitchell Grasslands has been submitted for external review and work is progression toward developing scenarios and conducting initial analyses for the Northern Downs region. • Work also has commenced towards defining a representative property and developing scenarios for the Mulga Lands region. • Spreadsheets have been developed that link GRASP modelling outputs with a modified version of Breedcow/Dynama and another bio-economic spreadsheet for the CWMG analysis. • Integrated sheep and beef software programs will be developed (combined Breedcow and Dynama with Breedewe and Sheepdyn) to allow consideration of trade-offs between wool sheep, meat sheep, meat goats, and cattle in the rangelands of western Queensland. **Delivery/ Extension Activities** • The project extension program was designed around what was most appropriate for each region and each region's DAF extension team and their existing projects (Maree Bowen, pers. comm., 2020). • In April 2018 a workshop was held in the Fitzroy region. The workshop aimed to help producers and advisors incorporate the new knowledge, identified in components 1 and 2, into an appropriate decision analysis framework that will improve decision making skills. • Central QLD (CQ) region DAF beef extension officers have incorporated key messages and content from the Fitzroy region report into their current extension material and presentations. • Key results from the Fitzroy region report also were presented at a plenary session at the International Animal Production Conference in Wagga Wagga. • A series of five one-hour BeefConnect webinars have been conducted to promote key results from the Fitzroy and Northern Gulf region analyses. 145 people listened to the first three seminars (live participants). The three BeefConnect webinars delivered to date had been viewed over 1,500 times on YouTube as of June 2019. • Project team member Fred Chudleigh (Principal Economist, DAF) delivered a five-day training session with the Western Australia (WA) Department of Primary Industries Regional Development (DPIRD) beef R&D team in August of 2018. The purpose of the training was to assist the WA beef R&D team in developing their own models to

	assess options across WA beef producing regions using the tools and approach developed in the DCAP project. • A CQ beef extension officer (Kylie Hopkins) presented components of the Fitzroy project results to 115 delegates at the International Leucaena Conference (ILC) in Brisbane in November 2018. • A case study article was produced by the CQ Beef Extension team and communicated through a FutureBeef ebulletin, the DCAP newsletter and in the QLD Country Life newspaper (December 2018). • A project page was uploaded to the FutureBeef website in February 2019. The site contains links to all products and information produced by the project to date (https://futurebeef.com.au/projects/improving-profitability-and-resilience-of-beef-and-sheep-businesses-in-queensland-preparing-for-responding-to-and-recovering-from-drought/) • A series of nine presentations have been recorded and made available on the DAF6 FutureBeef page to extend the project's drought response and recovery messages and tools developed to date. • Project team members (Fred Chudleigh and Maree Bowen) delivered a workshop in Julia Creek (QLD) in June 2019 to assist with assessing flood and drought recovery options for affected businesses as well as assessing best options for maximising long-term profitability. • An industry professionals information session was held in Longreach (QLD) in June 2019 to discuss the results and key messages from the Central West Mitchell Grasslands report with key DAF staff, producers and other industry professionals. Nine participants attended the session. • Results of the analyses produced to date have been presented at a number of conferences (domestic and international) and industry events. • The project has been, and continues to be, promoted in various media including through newsletters, eBulletins, Facebook posts etc. • By the end of the project, a program will be established for continued roll-out of the DSTs and framework the BMP and other FutureBeef programs. • It is likely that such a program would be funded through other DAF extension initiatives.
Outputs	• A report summarising the synthesis of scientific knowledge on the effect of management strategies designed to prepare, respond, and recover from drought, on pasture resilience and quality, animal nutrition and productivity. • Modified, property-level, regionally specific, herd/flock and business models, incorporating spreadsheets and decision support framework that can be used by consultants and advisors to assist producers to assess their own enterprise scenarios. The tools will be made available for download on various web sites including the Queensland Drought Mitigation Centre (QDMC) and FutureBeef platforms. • A report documenting scenario analyses for each region and recommendations on optimal strategies to (1) prepare for drought, (2) respond to drought, and (3) recover from drought. • Fact sheets and online resources designed for producers, providing a framework for decision making and summarising expected whole-farm impacts on production and profit of key management strategies.

	• Trained extension and technical staff from within DAF and NRM groups, as well as private consultants, in the use of the new and improved DSTs and framework. • Delivery of at least seven workshops to producers (one workshop in each target region). • A report detailing the extension and training activities conducted during the project including feedback from advisors, extension officers and producers. • A final project report synthesising learnings and recommendations from the project that may be used to inform future investment and policy. • A paper titled 'Evaluating the economics of phosphorus supplementation of beef cattle grazing northern Australian rangelands' was submitted to Animal Production Science (CSIRO publishing) in February 2019. • A third regional report, for the CWMG region, was approved for publication by the DAF Animal Science General Manager in October 2019. • DAF beef extension officers and economists participated in 18 producer workshops in the second quarter of the 2019/20 financial year. The workshops incorporated aspects of the DAF6 DCAP project results as a major component. • Key results of the project were presented at a number of conferences, lectures, and other presentations to industry. • Nine 'drought response and recovery' presentations recorded and uploaded to the DAF6 project page on FutureBeef: https://futurebeef.com.au/projects/improving-profitability-and-resilience-of-beef-and-sheep-businesses-in-queensland-preparing-for-responding-to-and-recovering-from-drought/. • An additional presentation (titled 'Modelling the improvement of beef production systems in northern Australia: farm management economics') was recorded and uploaded to the project web page. The objective of this presentation was to explain agricultural economic methods and terminology. • Three BeefConnect webinars delivered by Fred Chudleigh and Maree Bowen in June-July 2018 promoting key messages and results from Fitzroy and Northern Gulf regional analyses. • A number of journal articles/papers and media stories have been published. • The fourth regional report for the Northern Downs region was submitted in March 2020. • The following products have been prepared for upload to the DAF, Breedcow and Dynama software web page: i) to overcome Microsoft software support issues, all Breedcow and Dynama (BCD) spreadsheets have been updated to allow users to continue to download and access the tools from the DAF website. ii) The BCD user manual has been re-written to accommodate the changes to the software. iii) Regional base files for each of the DCAP analyses will be made available from the web page. iv) A total of 37 recorded presentation tutorials have been prepared which explain how to use the BCD spreadsheets and software. These have been reviewed and tested by regional DAF economists.

	• Work is continuing toward the development of scenarios and initial analyses for the Central West Rangelands and Mulga regions.
Outcomes	• DAF beef extension officers and continue to: a) incorporate key messages and content from the DAF6 regional DCAP reports into their extension material, and b) use the DCAP results to better target extension activities. • A number of industry professionals, consultants and advisors have been in contact with the project team following project workshops and/or presentations and now are using the information from the DCAP project reports/analyses as resources for themselves and/or their clients. • Elements of the Fitzroy report have been incorporated into learning materials by several universities (CQ University, Melbourne University, and the University of QLD). • DAF extension officers have delivered a number of producer workshops and producer visits incorporating information from the DCAP project reports to date. Such extension activity is ongoing. • The model developed as part of the Central West Mitchell Grasslands analysis has been adopted and adapted for use by regionally-based DAF economists as part of a Reef funded project titled ‘Investigating the relationship between profitability and ground cover on extensive grazing properties in the Fitzroy and Burdekin Catchments’. • More broadly, the regional reports and analyses and the accompanying DSTs and framework will be used by agricultural advisors and grazing enterprises to support the implementation of resilient grazing, herd/flock and business practices necessary to manage climate variability. • The property-level, regionally specific herd, flock and business models developed by the project may be used by consultants, advisors and producers to assess both strategic and tactical management decisions for their individual properties.
Impacts	• Increased average, annual productivity and profitability for some graziers (particularly beef and sheep grazing enterprises in QLD) through improved management decisions to prepare for, respond to, or recover from, drought and future climate variability. • Reduced variability of net farm incomes through improved farm management and decision making. • Improved soil condition for some pastural properties driven by decreased soil erosion and increase soil condition leading to improved water and nutrient retention (reduced run-off to external environments), and enhanced biodiversity. • Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) for the DCAP DAF6 project funded by DAF.

Table 2: Annual Investment in DCAP Project DAF6 (nominal $)

Contributor	2017/18	2018/19	2019/20	2020/21	Totals
DAF QLD (Contracted)	83,007	99,192	101,161	30,000	313,360
DAF QLD (In-Kind)	341,281	337,386	273,821	0	952,488
Others	0	0	0	0	0
Totals ($)	424,288	436,578	374,982	30,000	**1,265,848**

Source: DCAP project proposal and milestone variation documents

Program Management Costs

For all financial contributions including in-kind, any management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table 2.

Real Investment, Commercialisation and Extension Costs

No additional costs of extension were included as the project was extension focussed and encompassed a wide range of communication and extension activities.

Other Potential Costs

There are likely to be costs associated with the contribution of non-DAF personnel (e.g. producers, external advisers, other DAF staff, etc.) attending the DCAP DAF6 events/activities. However, to include accurate costs would require a full set of data on the number and type of events, how long the events ran for, the number of attendees, how far they travelled, and what they would have been doing had they not attended the DCAP event. Such detailed data were not readily available at the time of the current analysis and thus have not been included in the CBA and the total present value of costs (PVC) estimated may be an underestimate of the total costs for the DAF6 investment.

5. Impacts

The principal impacts from the DAF6 project investment were identified as:

- Increased average, annual productivity and profitability for some graziers (particularly beef and sheep grazing enterprises in QLD) through improved management decisions to prepare for, respond to, or recover from, drought and future climate variability.
- Improved soil condition for some pastural properties driven by decreased soil erosion and increase soil condition leading to improved water and nutrient retention (reduced run-off to external environments), and enhanced biodiversity.
- Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in QLD).
- Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry.
- Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Table 3 provides a summary of the types of impacts identified, categorised into economic, environmental and social impacts.

Table 3: Triple Bottom Line Categories of Potential Impacts from Investment in DAF6

Economic	• Increased average, annual productivity and profitability for some graziers (particularly beef and sheep grazing enterprises in QLD) through improved management decisions to prepare for, respond to, or recover from, drought and future climate variability. • Reduced variability of net farm incomes through improved farm management and decision making.
Environmental	• Improved soil condition for some pastural properties driven by decreased soil erosion and increase soil condition leading to improved water and nutrient retention (reduced run-off to external environments), and enhanced biodiversity.
Social	• Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Public versus Private Impacts

The primary impacts identified in this evaluation were industry related and therefore the benefits are considered private benefits. Private benefits are likely to accrue predominantly to beef and sheep producers (graziers) in QLD through increased profitability/ productivity and/or maintained social licence to operate.

Some public benefits also may be delivered in the form of improved environmental outcomes from improved grazing practices and the social benefits of increased industry capacity/ resilience and regional community spill-overs.

Distribution of Private Impacts

The primary beneficiaries of the DCAP DAF6 investment are graziers (beef and sheep) in QLD. Over time, it can be assumed that the benefits from the investment will be distributed between participants along commercial grazing supply chains according to relevant supply and demand elasticities.

Impacts on other Australian industries

The outputs of the DAF6 investment are likely to be relevant to beef and sheep (wool and meat) grazing enterprises across QLD and northern Australia (including northern WA) and also potentially to other grazing industries. Thus, it is possible that there may be impacts for other grazing primary industries and/or other regions in Australia. For example, members of the project team provided support to a WA DPIRD economist to assist WA rangeland beef producers utilising economic models and spreadsheets available through the DAF6 project. Further, goat meat producers were noted as having engaged in DAF6 project activities.

Impacts Overseas

No significant impacts to overseas parties were identified. However, the sharing of important project outputs, such as BMPs for grazing industries dealing with climate variability and/or drought, may have some impact on grazing industries in other countries.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, RD&E priorities are reproduced in Table 4. The DAF6 investment has contributed primarily to Rural RD&E Priority 4, with some contribution to Priority 3, and to Science and Research Priority 1, with some contribution to Priority 2.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[a] (est. 2015)	**Science and Research Priorities[b] (est. 2015)**
1) Advanced technology 2) Biosecurity 3) Soil, water and managing natural resources 4) Adoption of R&D	1) Food 2) Soil and Water 3) Transport 4) Cybersecurity 5) Energy and Resources 6) Manufacturing 7) Environmental Change 8) Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The Queensland Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: Queensland Government Research Priorities

Queensland Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1) Delivering productivity growth 2) Growing knowledge intensive services 3) Protecting biodiversity and heritage, both marine and terrestrial 4) Cleaner and renewable energy technologies 5) Ensuring sustainability of physical and especially digital infrastructure critical for research 6) Building resilience and managing climate risk 7) Supporting the translation of health and biotechnology research 8) Improving health data management and services delivery 9) Ensuring sustainable water use and delivering quality water and water security 10) The development and application of digitally-enabled technologies.	1) Real Future Impact 2) External Commitment 3) Distinctive Angle 4) Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

The DAF6 project addressed Queensland Science and Research Priorities 1 and 6. In terms of the guides to investment, the investment is likely to have real future impact through improved profitability and/or productivity of QLD grazing enterprises. Further, the DAF6 investment has been supported by a range of partners external to DAF and has provided resources, along with other DCAP Phase 2 investments, that have contributed to the critical mass for QLD grazing extension services to enable industry resilience.

6. Valuation of Impacts

Impacts Valued

Analyses were undertaken for total impacts that included future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of investment criteria.

Two primary impacts of the DCAP DAF6 investment were valued in monetary terms:

- Increased average, annual productivity and profitability for some graziers in western QLD through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience.
- Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD).

The DAF6 project evaluation forms part of a broader assessment of the DCAP Phase 2 investment. The two impacts identified above were valued at a DCAP Program level. Six DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to the two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

i. Though some benefits from the six contributing projects would accrue to graziers in the NT and the north of Western Australia (WA), the main emphasis of the DCAP projects was in QLD,
ii. The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising 49.8% of the national heard of 22.4 million head (ABS, 2020a). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and
iii. The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

Impacts Not Valued

Not all impacts identified in Table 3 could be valued in the assessment. Environmental and social impacts are difficult to value and may involve the application of non-market valuation techniques that were beyond the scope of the current assessment. Impacts were not valued due primarily to:

- A lack of evidence and/or data on which to base credible assumptions,
- The complexity of assigning monetary values to the impact (e.g. capacity built),
- Uncertainty regarding the pathways to impact, and
- The relative importance of the impact compared to the primary impact(s) valued.

The following impacts were not valued in the current analysis:

- Some contribution to improved environmental outcomes (e.g. reduced soil erosion) through improved pasture management.
- Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry.

- Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

A qualitative description of the impacts not valued and the reasons for not valuing them are provided below.

Contribution to improved environmental outcomes

Increased adoption of, and more effective implementation of, DSTs and/or models/frameworks/spreadsheets for responding to, and recovering from, drought by QLD grazing enterprises may lead to improved environmental outcomes (such as reduced soil erosion, improved soil quality and/or improved native vegetation and biodiversity).

Difficulties exist in identifying the specific environmental changes that may occur and then quantifying the value of such environmental benefits and linking the investments in the analysis to such impacts.

Increased regional community well-being

Regional communities linked to QLD grazing industries are likely to benefit from increased industry profitability and/or productivity. However, such spill-over benefits, such as increased economic activity and employment along the product supply chain, would be difficult to value, given the number and spread of production systems, subregions, and the availability of time and resources for valuation.

Increased industry capacity

The DAF6 investment supported a significant number of workshops, producer and industry stakeholder support activities, publications and other extension activities and materials. The project outputs have likely contributed to an increase in capacity for QLD grazing industry stakeholders, particularly producers and advisors, to utilise DSTs, models/ frameworks/ spreadsheets and other instruments to plan for, respond to, and recover from drought and future climate variability.

It is difficult to quantify the magnitude of such capacity enhancement because the initial level of capacity was unknown and placing a monetary value on human capacity requires the application of non-market valuation techniques that were beyond the scope of the current impact assessment. Also, to some extent, the capacity enhancement has been reflected via the productivity and profitability, and the social licence valuations.

Valuation of Impact 1: Increased Profitability and/ or Productivity for the QLD Grazing Industry

The investment in DAF6, along with five other DCAP Phase 2 projects (DES1, DES3, USQ4, DAF8 and DAF9), was assumed to have contributed to an increase in average, annual net farm income for QLD beef enterprises. The impact was divided between two types of beneficiaries:

1. Producers that were already utilising grazing BMPs, climate forecasting, models and DSTs for farm decision making that now make improved decisions as a result of the DCAP Phase 2 investment (existing users), and
2. New QLD producers adopting the use of grazing BMPs, climate forecasting, models and DSTs for farm decision making to improve profitability and productivity.

Specific assumptions used in the valuation are detailed in Table 6.

Valuation of Impact 2: Maintained Social Licence to Operate for the QLD Grazing Industry

The investment in DAF6, as part of the DCAP Phase 2 Program, has contributed to QLD beef producers adopting and/or improving on-farm animal and land management practices that, in turn, improve farmers' ability to respond to climate variability and drought, and potentially lead to improved environmental outcomes such as reduced erosion or improved native vegetation and biodiversity. Environmentally sensitive and responsive farm management was assumed to contribute to the maintenance or enhancement of the QLD grazing industry's social licence to operate.

Specific assumptions used in the valuation are detailed in Table 6.

Summary of Assumptions

A summary of the key assumptions made for the valuation of impacts is shown in Table 6.

Table 6: Summary of Assumptions

Variable	Assumption	Source
IMPACT 1: Increased Profitability and/ or Productivity for the QLD Grazing Industry		
Without DCAP Phase 2 Investment		
Average farm cash income for QLD beef producers	$163,645 per farm	5yr average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 2020a).
Average number of beef cattle enterprises in QLD	7,069	5yr average based on AgSurf population data for QLD beef (2015 to 2019) (ABARES, 2020a).
Current proportion of primary producers in QLD utilising climate forecasting, models, DSTs etc. for farm decision making	40%	Seasonal climate forecasts are used by 30 to 50% of agricultural producers in decision-making (Keogh et al., 2005; Keogh et al., 2004; Australian Government Department of Agriculture Fisheries and Forestry, 2004). The uptake of Seasonal Climate Forecasting (SCF) by agricultural producers in decision-making range from 30 to 50% (Cobon et al. 2017).
With DCAP Phase 2 Investment		
Part 1 (existing users): Proportion of existing users (primary producers) of climate forecasting, models, DSTs who have improved their decision	10%	¼ of existing users in QLD, conservative analyst assumption

making specifically due to DCAP Phase 2 investment		
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, DSTs etc.	5%	Conservative estimate based on a minimum profitability/ productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Part 2 (new users): Proportion of new QLD producers adopting the use of climate forecasting, models, DSTs etc. to improve on-farm decision making	20%	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).
Part 2 (new users): Attribution of practice change to DCAP2 investment for new users	50%	Acknowledges contribution of other drought resilience investments and previous investment in DCAP1.
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, DSTs etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of

		pasture growth by 26% (Brown et al. 2017).
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact	2024/25	Five years from first year of impact.
IMPACT 2: Maintained Social Licence to Operate for the QLD Grazing Industry		
Baseline data		
Average annual gross value of production (GVP) of QLD beef cattle	$5,206.2 million	5yr average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019)
With investment		
Profit as a proportion of GVP	10%	Agtrans Research, based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data 2017 to 2019) (ABARES, 2020b)
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment	10%	Analyst assumption.
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment	1.0%	Conservative estimate, analyst assumption (e.g. if current risk of loss of social licence is 5% p.a., this represents a reduction in risk to 4% p.a.).
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact	2024/25	Five years from first year of impact.
Risk factors (Impact 1 & 2)		
Probability of output	100%	Outputs have already been delivered.
Probability of outcome	100%	Already allowed for in the 10% of QLD beef enterprises at risk.
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the

		benefits estimated may not persist into the future
Other Factors (Impact 1 & 2)		
Attribution of benefits to the specific investment in DAF6 as part of the DCAP Phase 2 Program	3.7%	Based on the relative investment in DAF6 compared to the total investment across the six contributing projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9)
Additional costs	Based on the assumptions made, the benefits estimated were assumed to be NET of any additional adoption and/or implementation costs incurred by producers	

Counterfactual

The counterfactual, or what would have happened in the absence of the DCAP Phase 2 investments, includes the scenario that some additional and improved adoption of grazing BMPs (animal and land management) would have occurred without the DAF6 investment, given the range of other investments by other organisations (e.g. existing DAF beef extension program). This scenario is allowed for in the valuation by considering only the improvements (e.g. increased adoption leading to increased average net farm income) specifically attributable to the DCAP Phase 2 investment

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020b). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Table 7 and Table 8 show the investment criteria estimated for different periods of benefits for the total investment and the DCAP (DAF) investment respectively. The present value of benefits (PVB) attributable to DCAP investment only, shown in Table 8, has been estimated by multiplying the total PVB by the DCAP proportion of real investment (24.7%).

Table 7: Investment Criteria for Total Investment in DAF6

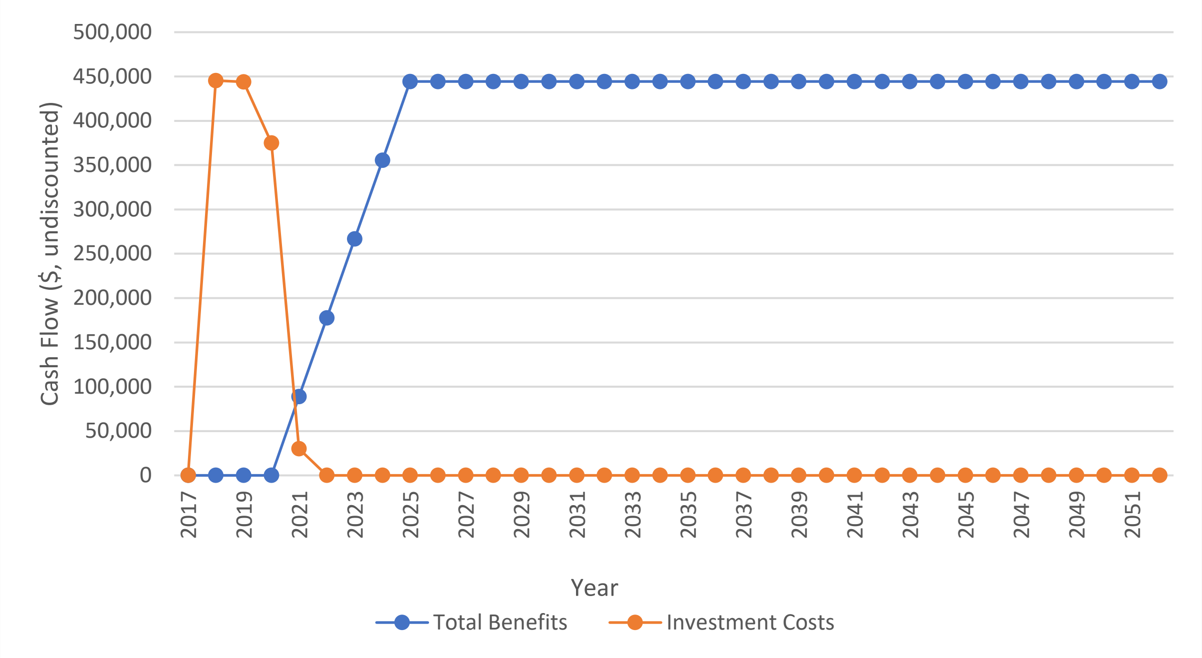
Investment criteria	**Number of years from year of last investment in the DCAP Phase 2 Program**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.25	1.76	3.13	4.20	5.04	5.70	6.22
Present value of costs ($m)	1.36	1.36	1.36	1.36	1.36	1.36	1.36
Net present value ($m)	-1.11	0.40	1.77	2.84	3.68	4.34	4.85
Benefit-cost ratio	0.18	1.30	2.30	3.09	3.71	4.19	4.57
Internal rate of return (%)	negative	9.94	17.32	19.21	19.82	20.03	20.13
MIRR (%)	negative	8.12	10.95	10.22	9.24	8.36	7.62

Table 8: Investment Criteria for DCAP (DAF) Investment in DAF6

Investment criteria	**Number of years from year of last investment in the DCAP Phase 2 Program**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.06	0.44	0.77	1.04	1.24	1.41	1.53
Present value of costs ($m)	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Net present value ($m)	-0.27	0.10	0.44	0.70	0.91	1.07	1.20
Benefit-cost ratio	0.18	1.31	2.33	3.12	3.75	4.24	4.62
Internal rate of return (%)	negative	10.39	17.93	19.82	20.42	20.62	20.70
MIRR (%)	negative	8.56	11.34	10.52	9.48	8.56	7.79

The annual undiscounted benefit and cost cash flows for the DAF6 total investment for the duration of investment period plus 30 years from the last year of investment in the DCAP Phase 2 Program (2021/22) are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Gross Benefits and Total Investment Costs



Source of Benefits

Estimates of the relative contribution of each benefit valued, given the assumptions made, are shown in Table 9. It should be noted that approximately 96.5% of the total benefits estimated was derived from increased average, annual net farm income because of increased adoption of, or improved implementation of, grazing BMPs, climate forecasts, models and DSTs.

Table 9: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Impact 1: Increased profitability/ productivity for QLD beef enterprises	6.00	96.5
Impact 2: Maintenance of social licence for QLD beef enterprises	0.22	3.5
Total	6.22	100.0

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 10 presents the results that showed a moderate sensitivity to the discount rate. This was due largely to the fact that the benefit cash flows occur well into the future and therefore are subjected to more significant discounting effects.

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

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	13.33	6.22	3.50
Present value of costs ($m)	1.29	1.36	1.43
Net present value ($m)	12.04	4.85	2.07
Benefit-cost ratio	10.30	4.57	2.45

Other sensitivity analyses including were carried out and reported at the DCAP Program level due to the valuation frameworks being extended to cover multiple DCAP Phase 2 projects. This was driven by the pathways to impact being common to each of the three impacts.

Confidence Ratings 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 impacts valued. Where there are multiple types of impacts it is often not possible to quantify all impacts 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 11). 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 11: Confidence in Analysis of Project

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

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

Confidence in assumptions for the valuation also was rated as Medium. This was because of the fact that, though many of the assumptions were based on credible data and published literature, there has been little evidence of impacts to date as the DCAP Phase 2 investments are ongoing. Further, the DCAP Program evaluation necessitated valuation of some impacts at a broader level, and thus some of the assumptions were somewhat uncertain.

8. Conclusions

The investment in the DAF6 project over the years ending June 2018 to June 2021 is likely to be successful and is on track to deliver impacts for QLD graziers, the environment and the Australian and QLD governments.

The principal benefits delivered by the project will accrue to beef and sheep producers in QLD from improved on-farm decision making, leading to more productive, profitable and resilient grazing enterprises, and avoidance of some potential loss in social licence to operate. Some of these benefits are likely to be shared along the product supply chain due to increased economic activity (e.g. in product transporting and processing). Some public benefits may also be delivered via increased industry and community resilience and community spill-overs from increased, or at least maintained, producer incomes

The total investment in the project of $1.33 million (present value terms) has been estimated to produce total gross benefits of $6.22 million (present value terms) providing a net present value of $4.89 million, a benefit-cost ratio of 4.67 to 1 (using a 5% discount rate over 30 years), an internal rate of return of 20.5% and a modified internal rate of return of 7.7%. Despite the fact that the PVC may have been underestimated since some potential costs were not able to be included in the analysis (e.g. costs associated with non-DAF personnel attending DCAP DAF6 events/activities), based on the conservative assumptions made and the fact that a number of benefits were identified but not valued, the investment criteria reported are likely to be an underestimate of the true performance of the DAF6 investment as several impacts identified were not valued in monetary terms.

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Appendix 7: Impact Assessment of 'The Use of Bureau of Meteorology (BoM) Multi-Week and Seasonal Forecasts to Facilitate Improved Management Decisions in Queensland's Vegetable Industry' (Project DAF7)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research

in conjunction with AgEconPlus

August 2020

Contents

List of Tables and Figures

Acknowledgments

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Abbreviations

BCR	Benefit-Cost Ratio
BoM	Bureau of Meteorology
CBA	Cost-Benefit Analysis
DAF	Department of Agriculture and Fisheries – Queensland
DCAP	Drought and Climate Adaptation Program
GVP	Gross Value of Production
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
NSW	New South Wales
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current project investment (DAF7, *The Use of Bureau of Meteorology (BoM) Multi-Week and Seasonal Forecasts to Facilitate Improved Management Decisions in Queensland's Vegetable Industry*) within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP).

The project is described qualitatively using a logical framework that includes project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts are then estimated in dollar terms.

Potential benefits are estimated for a range of time frames up to 30 years from the last year of investment in the project (2020/21). Past and future cash flows in 2019/20 dollar terms are discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) has been conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The investment in DAF7 has delivered experimental multi-week and seasonal forecasts to vegetable growers in the Granite Belt and Lockyer Valley along with a package of management decisions that can be used to improve business sustainability and profitability. The project was also expanded to include the Bowen region.

In summary, the total investment in the project has produced several impacts and a key benefit has been valued. The total investment of $0.98 million (present value terms) has been estimated to produce total gross benefits of $4.53 million (present value terms) providing a net present value of $3.55 million, a benefit-cost ratio of 4.6 to 1 (using a 5% discount rate), an internal rate of return of 30.1% and a modified internal rate of return of 9.9%.

As one unsolicited grower noted "This is perhaps one of the most worthwhile projects undertaken by a government department in a long time. Surely having a better understanding of our ever changing climate has to be the greatest management tool for grower that he can use".

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background & Rationale

Background
Climate variability over multiple weeks and throughout the growing season has a significant impact on horticultural production. In particular, variation in temperature and rainfall affects horticulture's location, timing, and productivity.

Horticulture in Queensland (QLD) includes the production of lettuce and broccoli in the Granite Belt during summer and counter season supply from the Lockyer Valley during winter. Sweet corn is grown in both regions during summer. Other vegetable crops include pumpkin production. The gross value of production (GVP) of vegetables in the Granite Belt is approximately $200 million per annum while in the Lockyer Valley it is around $400 million. In both regions, vegetable production businesses are major employers and community drivers (David Carey, written comm., Principal Investigator and Senior Horticulturalist, DAF).

Rationale for the investment
Heat waves significantly reduce the quality and supply of lettuce, broccoli, and sweet corn. If reliable multi-week temperature forecasts were available to growers there are a range of management options growers and the supply chain can adopt to mitigate their losses.

In 2013, Hort Innovation funded a project (VG13092) to develop experimental seasonal forecasts based on BoM's next-generation forecasting system, ACCESS-S1. Experimental products focussed on the 2-4 week and 1-4 month timescales for both temperature and rainfall and were prepared for nine important horticultural production regions across Australia. The two highest value vegetable production regions in Queensland (Lockyer Valley and Granite Belt) were not included in the Hort Innovation project. Additional experimental and operational multi-week and seasonal forecasts were also available from BoM for use in a new project. DAF note that there was little engagement with producers or the supply chain in the previous work (David Carey, written comm., Principal Investigator and Senior Horticulturalist, DAF).

This DCAP project (DAF7) targeted key vegetable crop growers and supply chain businesses significant to the Queensland economy and based in the Granite Belt and the Lockyer Valley. This complimentary choice of a summer and winter production region was strategic, allowing the ground truthing of experimental multi-week and seasonal forecasts with growers and their supply chains (packer/marketers) continuously over 12 months and in climatically different regions. The project team worked closely with vegetable businesses to document and identify management decisions that can be improved with advanced knowledge of future temperature and rainfall events; and increase grower/supply chain profitability.

3. Project Details & Logical Framework

The project is described in a logical framework in Table 1.

Table 1: Project Logical Framework

Code and Title	DAF7: The Use of BoM Multi-Week and Seasonal Forecasts to Facilitate Improved Management Decisions in Queensland's Vegetable Industry.
Project Details	Organisation: DAF. Period: August 2017 to June 2021. Principal Investigator: David Carey.
Objectives	1. Ground truth ACCESS-S1 multi-week and seasonal forecasts developed as part of Hort Innovation project VG13092 as well as other BoM forecasts in collaboration with vegetable industry supply chain participants in two regions of South East QLD (the Granite Belt and the Lockyer Valley)[1]. 2. Document management decisions which can be significantly improved with knowledge of future temperature and rainfall events. Improved knowledge will positively impact risk, profitability, product quality and the reliability of vegetable supply. 3. Recommend to BoM the development of operational products from these experimental forecasts. These products will improve the capacity of primary producers to manage climate variability.
Activities and Outputs	• Ground truth the ACCESS-S1 multi-week and seasonal forecasts developed as part of VG13092 along with other BoM forecasts with vegetable growers and the vegetable supply chain. • Convene workshops with growers and supply chain participants in the Granite Belt and Lockyer Valley regions. Twenty four businesses took part in workshops in the Granite Belt (85% of the industry) and 32 businesses took part in the Lockyer Valley (80% of the industry). In total these businesses accounted for more than 6,000 ha of vegetable production. • Identify vegetable management decisions that can be improved with advanced knowledge of future temperature and rainfall events. • Improved management decisions were identified, forecasts were assessed and documented including case study applications. • Workshops were held with growers and supply chain participants, improved management decisions were identified, hindcasting and case studies were discussed. • Identification of verified useful forecasts. Criteria included: are the forecasts reliable? Is there sufficient skill for these forecasts to be useful? Do the forecasts offer the potential for improved management decisions? Have improved management decisions been identified? Have these decisions positively impacted risk and profitability, and/or product quality and reliability of production and supply? • Mid-term project review - two years of ground truthing ACCESS-S1 multi-week and seasonal and retrospective case studies from hindcasts. The review was positive, and the project will continue through to June 2021. • Further adjustment and validation of forecasts is to be undertaken. • Project outputs are already proving to be useful to Granite Belt and Lockyer Valley vegetable growers. Growers are using forecasts to make decisions about whether to plant, area to plant and irrigation planning and timing. For example, a single large grower participating in the project

[1] At the request of two large agribusinesses operating in the Granite Belt and Lockyer Valley, the project was later expanded to include the Bowen region.

	reported that use of project seasonal forecasts, along with other sources of forecast information, resulted in a decision to stop planting vegetables in the summer of 2019/20 saving the grower $45,000 per week in production costs for what would prove to be a failed crop. • Recommendations to BoM for the development of operational products which will improve the capacity of vegetable growers and the supply chain to manage climate variability. Recommendations will be made in June 2021.
Outcomes (potential)	• Vegetable growers and supply chain partners in the Granite Belt and Lockyer Valley accessing and making use of reliable multi-week and season long forecasts, applying management decisions, reducing income variability, and increasing profit.
Impacts (potential)	• Economic – reduction in vegetable (lettuce, broccoli, sweet corn) income loss (revenue and production cost loss) caused by extreme heat and rainfall events that affect yield, quality, and the level of vegetable waste. • Economic – more consistent and better quality supply of fresh vegetables for packer/marketers. • Environmental – improved crop management with decreased loss of soil to waterways, increased fertiliser efficiency and an improvement in the vegetable industry's social licence to operate. • Capacity – vegetable growers with new skills and improved knowledge of climate forecasting and the interpretation of forecast information. • Capacity – BoM staff with an improved understanding of the forecast needs of the vegetable and horticultural industries. • Capacity – DAF researchers with new skills in climate forecasting and management response. • Social – operational forecast products are more user friendly and more easily understood and interpreted by the Australian and international agricultural sectors. • Social – contribution to improved regional community wellbeing (income and employment) from spill-over benefits from more profitable/less variable vegetable production.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) for the project with funding provided by DAF.

Table 2: Annual Investment in the Project for Years Ending June 2018 to June 2021 (nominal $)

Contributor	2018	2019	2020	2021	Total
DAF - cash	88,050	69,145	69,932	41,061	268,188
DAF – in-kind	149,692	156,261	163,067	197,972	666,992
Total	237,742	225,406	232,999	239,033	935,180

Source: DCAP project proposal and DCAP Dashboard V16.

Program Management Costs

For the DAF investment, the management and administration costs for the project are already built into the nominal dollar amounts appearing in Table *2*.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20-dollar terms using the Implicit GDP Deflator index (ABS, 2020). Industry extension and communication is underway with 85% of the production base of the Granite Belt and 80% of the production base of the Lockyer Valley as part of the project.

5. Impacts

An overview of potential impacts in a triple bottom line categorisation is shown in Table 3.

Table 3: Categories of Impacts from the Investment

Economic	Environmental	Social
Reduction in vegetable (lettuce, broccoli, sweet corn) income loss (revenue and production cost loss) caused by extreme heat and rainfall events that affect yield, quality, and the level of vegetable waste. More reliable supply of fresh vegetables for packer/marketers.	Improved crop management with decreased loss of soil to waterways, increased fertiliser efficiency and an improvement in the vegetable industry's social licence to operate.	Vegetable growers with new skills and improved knowledge of climate forecasting and the interpretation of forecast information. BoM staff with an improved understanding of the forecast needs of the vegetable and horticultural industries. DAF researchers with new skills in climate forecasting and management response Operational forecast products are more user friendly and more easily understood and interpreted by the Australian and international agricultural sectors. Contribution to improved regional community wellbeing (income and employment) from spill-over benefits from more profitable/less variable vegetable production.

Public versus Private Impacts
The impacts identified from the investment are mostly private in nature. Private impacts accrue to vegetable growers in the form of reduced income loss caused by extreme heat and rainfall events and improved turnover and profit from better business decisions. Public impacts include capacity building in growers, BoM forecasters and DAF research staff, and community spill-over benefits associated with more profitable/less variable vegetable production and improved environmental outcomes.

Impacts Accruing to other Primary Industries
Forecast tools tested and operational products subsequently released by BoM will have relevance to the full gambit of agricultural production in the Lockyer Valley and Granite Belt regions e.g. wine grape and apple production in Stanthorpe. The DAF7 project team has also contributed to the way BoM displays all of its forecast information and this is relevant to primary industries in all locations.

Distribution of Benefits along the Supply Chain

Some of the potential benefits accruing to vegetable growers in the form of reduced income loss and improved turnover/profit from better business decisions will be shared along the supply chain with packers, wholesalers, exporters, retailers, and consumers.

Impacts Overseas

Forecasts and management responses developed as part of this project will only have relevance to the Australian situation. However, a more secure production base as a result of the application of multi-week/seasonal forecast products will add to the reliability of local export products. The supply chain businesses participating in this project include processors of value added and semi-processed QLD export products e.g. bagged salad, fresh cut vegetables.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 4. The investment in seasonal forecasts for vegetable growers is relevant to Rural RD&E Priority 1, 3, 4 and to Science and Research Priority 1, 2 and 7.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[(a)] (est. 2015)	**Science and Research Priorities[(b)] (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

The investment addressed QLD Science and Research Priorities 1, 2, 6 and 9. In terms of the guides to investment, the investment is likely to have a real future impact on the vegetable industry (Decision Rule 1) and, through BoM, was well supported by others external to the QLD Government (Decision Rule 2).

6. Valuation of Impacts

Impacts Valued in Monetary Terms
Analyses were undertaken for total impacts that included future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of investment criteria.

The impact valued was additional income from better business decisions/reduction in vegetable income loss caused by extreme heat and rainfall events in the Granite Belt and Lockyer Valley.

Impacts not Valued in Monetary Terms
Not all impacts identified in Table 3 could be valued in the assessment. One impact was not valued due to a lack of data (more reliable supply of fresh vegetables for packer/marketers) and others were not valued due to the complexity of assigning monetary values to the impact (environmental improvement, capacity built and increased regional income and employment).

Valuation of Impact 1: Additional Income from better business decisions/Reduction in Vegetable Income Loss Caused by Extreme Events
With access to reliable multi-week and seasonal forecasts growers will be able to make more informed decisions about the management of their vegetable crops and reduce income loss associated with extreme weather/climate events. For example, growers with limited water supply may be able to use seasonal forecasts to make decisions on whether it is prudent to plant vegetable crops at the beginning of a season with an extreme heat/extreme dry outlook. In this instance, informed decisions made after consideration of multi-week and seasonal forecasts will save the grower substantial planting costs[2].

This approach was confirmed with DAF "A significant Granite Belt grower reported that after our DCAP Experimental Forecast meeting, a decision was made to cease planting of any new crop as there will not be enough water to get the crop to maturity. This decision saved planting costs of around $4,500 a week, as with no likelihood of useful rain and above average summer temperatures forecast, the chance of getting any marketable yield when the crops mature in 2 to 3 months' time was extremely low. This grower also leased land and sourced product from another district, allowing them to keep supplying prepacked trimmed vegetables to a high value national food chain. This proven reliability through a hot dry summer when other suppliers had problems has resulted in this business acquiring additional supply volume under this lucrative contract" (David Carey, Principal Investigator and Senior Horticulturalist, DAF, written comm., February, and June 2020).

Attribution
The project was reliant on a previous investment in the development of experimental seasonal forecasts (VG13092) and use by growers of other sources of forecast information (BoM Outlook, BoM 7-day forecast, BoM MetEye, and BoM Heatwave Forecast). After considering this information, an attribution factor of 45% has been applied. Following DAF feedback on the draft analysis, the attribution factor was sensitivity tested at 75%.

[2] DAF note that growing costs will also be saved (spraying, watering, fertilising) and that in some instances businesses have moved production and grown product in a different location allowing them to keep scarce long-term supply contracts, retain their staff and increase cash flow. DAF also note that the success of the forecast products has encouraged their use in other production regions and states.

Counterfactual
In the absence of DAF7 the assumption is made that it is 50% likely that another research project would have made similar progress in creating reliable multi-week and seasonal forecasts (e.g. investments made through the Australian Government Rural R&D for Profit Program, round 1 through to 3). Following DAF feedback on the draft analysis, the counterfactual was sensitivity tested at 10% i.e. unlikely that the project would be completed through another investor.

A summary of project assumptions and data source is provided in Table 6.

Table 6: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
Impact 1: Additional Income from Better Business Decisions/Reduction in Vegetable Income Loss Caused by Extreme Events		
Area of the Granite Belt and Lockyer Valley planted to vegetables.	6,000ha.	David Carey, pers. comm., Principal Investigator and Senior Horticulturalist, DAF, written comm., February 2020.
Vegetable planting costs	$3,558/ha.	Estimate derived after considering Carey et al (2017) which estimated broccoli planting costs of $6,190/ha in the Lockyer Valley and DAF Agbiz (2006, 2007) planting costs for sweet corn of $770/ha (CPI adjusted) and $3,558/ha (CPI adjusted) for both broccoli and lettuce in South East QLD.
Frequency of extreme weather/climate event	1 in 3 years.	Consultant estimate after considering historical weather data. DAF note the possibility of increased frequency with climate change.
Year in which extreme weather/climate forecasting tools become available to vegetable growers.	2022	Year after project completion.
Share of Granite Belt and Lockyer Valley production adopting forecast products first year available.	20%	Consultant estimate
Year in which adoption of forecasts is maximised.	2027	Consultant estimate.
Maximum share of Granite Belt and Lockyer Valley production adopting forecast products.	80%	Consultant estimate
Year in which project forecasts are replaced with superior products.	2032.	Consultant estimate.
Attribution of impacts to DAF7.	45% (sensitivity tested at 75%).	The project was reliant on a previous investment in the development of experimental seasonal forecasts (VG13092) and use by growers of other sources of forecast information.

Probability of output.	75%	Consultant estimate.
Probability of impact.	90%	There is some possibility that the forecast products delivered as part of the project will not persist for the next 10 years.
Counterfactual.	50% (sensitivity tested at 10%).	In the absence of DAF7 it is 50% likely that another research project would have made similar progress with forecast products (e.g. investments made through the Australian Government Rural R&D for Profit Program).

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21) to the final year of benefits assumed (2050/51).

Investment Criteria

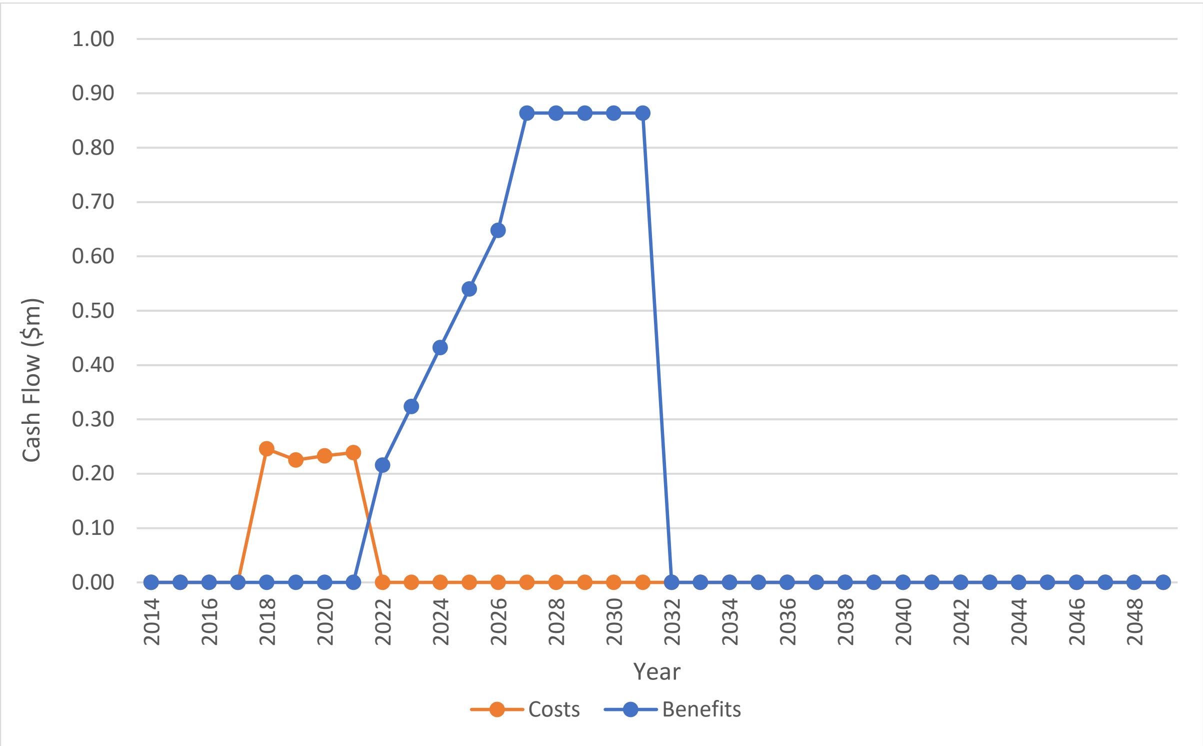
Table 7 shows the investment criteria estimated for different periods of benefits for the total investment. DAF was the only investor in the project so no second set of analyses showing returns to DAF investment is required.

Table 7: Investment Criteria for Total RD&E Investment in DAF7

Investment criteria	Number of years from year of last investment						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.20	1.74	4.53	4.53	4.53	4.53	4.53
Present value of costs ($m)	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Net present value ($m)	-0.78	0.76	3.55	3.55	3.55	3.55	3.55
Benefit-cost ratio	0.20	1.78	4.64	4.64	4.64	4.64	4.64
Internal rate of return (IRR) (%)	negative	17.94	30.09	30.09	30.09	30.09	30.09
Modified IRR (%)	negative	11.94	17.16	13.83	11.93	10.70	9.85

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 1.

Figure 1: Annual Cash Flow of Undiscounted Total Net Benefits and Total RD&E 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.

Table 8 shows that investment criteria are not overly sensitive to the discount rate and remain positive at a 10% discount rate, twice the rate of the base assessment.

Table 8: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	6.48	4.53	3.27
Present value of costs ($m)	0.95	0.98	1.00
Net present value ($m)	5.53	3.55	2.26
Benefit-cost ratio	6.81	4.64	3.25

A sensitivity analysis was completed on the frequency of extreme weather/climate events (Table 9). Results show that even with a 25% frequency (1 event every four years), returns from the investment remain positive.

Table 9: Sensitivity to Frequency of Extreme Weather/Climate Event
(Total investment, 30 years)

Investment Criteria	**Frequency of Extreme Weather/Climate Event**		
	1 in 4 years	**1 in 3 years (base)**	**1 in 2 years**
Present value of benefits ($m)	3.40	4.53	6.80
Present value of costs ($m)	0.98	0.98	0.98
Net present value ($m)	2.42	3.55	5.82
Benefit-cost ratio	3.48	4.64	6.96

A further sensitivity analysis was completed on the share of production in the Granite Belt and Lockyer Valley adopting forecast products (Table 10). Results show that if only 18% of production adopts project forecasts, then the project will breakeven.

Table 10: Sensitivity to Share of Production Adopting Seasonal Forecasts
(Total investment, 30 years)

Investment Criteria	**Maximum share of Granite Belt and Lockyer Valley production adopting forecast products**		
	Breakeven (18%)	**40%**	**80% (base)**
Present value of benefits ($m)	1.03	2.27	4.53
Present value of costs ($m)	0.98	0.98	0.98
Net present value ($m)	0.05	1.29	3.55
Benefit-cost ratio	1.05	2.32	4.64

A final set of sensitivity analyses was complete following DAF comments on the draft impact assessment. Table 11 shows BCRs of 7.7% and 8.4% when attribution factor is increased to 75% and counterfactual is 10%.

Table 11: Sensitivity to DAF Suggestions for Attribution and Counterfactual
(Total investment, 30 years)

Investment Criteria	DAF Suggestions for Attribution and Counterfactual		
	(base)	Attribution (75%)	Counterfactual (10%)
Present value of benefits ($m)	4.53	7.55	8.15
Present value of costs ($m)	0.98	0.98	0.98
Net present value ($m)	3.55	6.57	7.17
Benefit-cost ratio	4.64	7.73	8.35

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 12). 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 12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

Coverage of benefits was assessed as medium. While the key economic benefit was quantified (reduction in vegetable income loss caused by extreme events), the benefit to packer/marketers, the environment, capacity building and regional community wellbeing were not.

Confidence in assumptions was rated as medium. Assumptions applied in valuing impacts were mostly drawn from credible sources.

8. Conclusion

The investment in this project has delivered experimental multi-week and seasonal forecasts to vegetable growers in the Granite Belt and Lockyer Valley along with a package of management decisions that can be used to improve business sustainability and profitability. The project was also expanded to include the Bowen region.

In summary, the total investment in the project has produced several impacts and a key benefit has been valued. The total investment of $0.98 million (present value terms) has been estimated to produce total gross benefits of $4.53 million (present value terms) providing a net present value of $3.55 million, a benefit-cost ratio of 4.6 to 1 (using a 5% discount rate), an internal rate of return of 30.1% and a modified internal rate of return of 9.9%.

Benefit-cost ratios for agricultural RD&E projects typically fall in the band between 2 and 5. This project has been estimated to create potential benefits in the performance upper range. As one unsolicited grower noted “This is perhaps one of the most worthwhile projects undertaken by a government department in a long time. Surely having a better understanding of our ever changing climate has to be the greatest management tool for grower that he can use”.

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Appendix 8: An Impact Assessment of ‘Building Drought Resilience (GrazingFutures)’ (Project DAF8)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research

in conjunction with AgEconPlus

August 2020

Contents

List of Tables and Figures

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Abbreviations

BCR	Benefit-Cost Ratio
BMP	Best Management Practice
BoM	Bureau of Meteorology
CBA	Cost-Benefit Analysis
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
DCAP	Drought and Climate Adaptation Program
DES	Department of Environment and Science (Queensland)
DST	Decision Support Tool
GFNGN	GrazingFutures Northern Grazing Network
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
MLA	Meat and Livestock Australia
NPV	Net Present Value
NRM	Natural Resource Management
NT	Northern Territory
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
RFDS	Royal Flying Doctor Service
SCF	Seasonal Climate Forecasting
USQ	University of Southern Queensland

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a Queensland Department of Agriculture and Fisheries (DAF) investment in a project known as *DAF8: Building Drought Resilience (GrazingFutures)*. The project was one of a suite of projects funded under the second iteration of DAF's Drought and Climate Adaptation Program (DCAP). The DCAP project DAF8 was funded by DAF for the years ended 30 June 2018 to 2021.

The project was first analysed qualitatively using a logical framework approach that included a description of project objectives, activities and outputs, and actual and potential outcomes and impacts. Impacts were categorised into a triple bottom line framework. Principal impacts were then valued.

Benefits were estimated for a range of time frames up to 30 years from the last year of investment in the DCAP Phase 2 Program (2021/22). Past and future cash flows in 2019/20 dollar terms were discounted to the year 2019/20 (year of analysis) using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis was conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The major impacts identified were economic/financial in nature. However, some social and environmental impacts also were identified but not valued. It is expected that Queensland (QLD) graziers, particularly those in Western QLD, will be the major beneficiaries. Impacts include increased average annual net farm income for QLD beef producers, potentially improved environmental outcomes, maintained social licence to operate, increased industry resilience, and increased regional community wellbeing.

The total investment in the project of $6.05 million (present value terms) has been estimated to produce total gross benefits of $27.88 million (present value terms) providing a net present value of $21.83 million, a benefit-cost ratio of 4.61 to 1 (using a 5% discount rate over 30 years), an internal rate of return of 21.4% and a modified internal rate of return of 8.0%. Despite the fact that the present value of costs may have been underestimated since some potential costs were not able to be included in the analysis (e.g. costs associated with non-DAF personnel attending DCAP DAF8 events/activities), based on the conservative assumptions made and the fact that a number of benefits were identified but not valued, the investment criteria reported are likely to be an underestimate of the true performance of the DAF8 investment as several impacts identified were not valued in monetary terms.

1. Evaluation Methods

The evaluation approach 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. This impact assessment uses cost-benefit analysis as its principal tool. The approach includes both qualitative and quantitative analyses that are in accord with the current evaluation guidelines of the Council of Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, and potential and actual outcomes and impacts. The principal economic, environmental and social impacts are then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, the difficulty in defining the pathway to impact (linking the impact to the original investment), or the likely low relative significance of the impact compared to those that were valued. The impacts valued therefore are deemed to represent the principal benefits delivered by the project.

2. Background and Rationale

Background

The Drought and Climate Adaptation Program

The Drought and Climate Adaptation Program (DCAP) is an initiative led by the Queensland Department of Agriculture and Fisheries (DAF) that aims to help Australian producers better manage drought and climate impacts through research that will help manage financial risks and decision making around droughts and climate variability through improved forecast products, tools and extension activities (Queensland Government, 2020).

DCAP commenced with Phase One in 2015/16. Phase One ended June 2017 and the Program is now in Phase Two that will run to June 2021 and consists of nine integrated research, development and extension (RD&E) investments (Coutts J&R, 2019). DCAP's major funding partners include DAF, the Department of Environment and Science (DES), the University of Southern Queensland (USQ), the Bureau of Meteorology (BoM), and Meat and Livestock Australia (MLA).

DCAP and the Grazing Industry

Managing climate variability and drought is a significant challenge for the Australian grazing industry. Despite programs and resources (such as the Grazing Best Management Practice (BMP) guidelines), evidence suggests that many grazing enterprises in Queensland (QLD) and northern Australia fail to effectively manage climate variability and improve their capability to prepare for future drought cycles (McCartney, 2017). McCartney (2017) identified a number of factors that may limit decision making for drought preparedness and management in QLD grazing enterprises. Factors included:

- A grazier's financial and economic situation,
- The nature of grazing production systems,
- The management focus of a grazier such as record keeping, planning and decision-making systems,
- Graziers' knowledge, willingness and capacity to learn and change,
- Graziers' personal attitudes and circumstances, and
- The role of Government.

The 2017 report also identified a number of future opportunities to address key limitations and improve management and decision-making for drought and climate variability for QLD grazing businesses. Future opportunities were grouped into six categories as follows (McCartney, 2017):

1. Increase extension services and other independent service providers,
2. Develop decision-support services, tools and aids,
3. Reform drought assistance arrangements,
4. Support drought-related research and development,
5. Challenge industry and community attitudes to drought, and
6. Promote industry diversification and off farm investment.

A number of DCAP project investments have been targeted at addressing such opportunities and improving drought preparedness and climate adaptation for grazing businesses in QLD and northern Australia.

Rationale for the Current Investment

Queensland has experienced an extended drought period since 2012/13. Currently, a total of 41 councils and four part council areas are drought declared with western[1] QLD the worst affected (Queensland Government, 2019). However, above average projected rainfall for the Spring/Summer periods of recent years (2016/17 onward) presented an opportunity for industry, Government and other stakeholders across QLD to focus their attention on potential drought recovery while, at the same time, identifying how landholders can gain knowledge and skills for resilience when they encounter future droughts (Roberts & Long, 2017).

The DCAP (Phase 2) project titled '*DAF8: Building Drought Resilience (GrazingFutures)*' (hereafter referred to as DAF8) was funded to provide coordinated training and extension services to assist land managers to be better skilled in business, production and land management to improve drought resilience. The project is targeted at three regions of north, central, and south in western QLD.

[1] Western QLD is defined as Northern Gulf, Southern Gulf, Desert Channels QLD, and South-West NRM regions plus the Maranoa and Balonne Council areas.

3. Project Details & Logical Framework

Summary of Projects

DCAP Project Code	Project Title	Project Leader	Funding Period
DAF8	Building Drought Resilience (GrazingFutures)	Joe Rolfe, Principal Beef Extension Officer (Mareeba), DAF	DCAP Phase 2: 2017/18 to 2020/21

Logical Framework

Table 1 provides a description of the project using a logical framework approach.

Table 1: Logical Framework for DCAP Project DAF8

Aspirational Goal	To provide coordinated training and extension services to assist land managers to be better skilled in business, production and land management for improved drought resilience.
Objectives	Specific objectives of the project are to: • Prioritise the delivery of workshops, training and targeted support within the themes of people and business, grazing and land management and animal production based on verifiable industry needs, data and regional drought conditions. • Support grazing businesses in western QLD to improve business resilience, drought recovery and future drought preparedness. • Improve the skills and capability of grazing industry support officers from both the public and private sectors to facilitate improvement in business resilience, drought recovery and future drought preparedness of grazing businesses in western QLD. • Partner with government, non-government agencies and other partners in a co-innovation approach to deliver comprehensive support to grazing businesses and value add to existing services. • Analyse and document key learnings from grazing businesses adopting objective measurement to enhance drought recovery, increase future drought preparedness and plan for other business risks.
Activities	• A number of Grazing BMP[2] workshops have been held across the south, central and north region of QLD. • Five Grazing BMP workshops conducted in the south region with a target to increase awareness of Grazing BMP by 1,150 people. • Three Grazing BMP workshops conducted in the central region with a target to increased awareness by 300 people. • Four Grazing BMP workshops conducted in the north region with a target to increase awareness by 200 people. • The workshops are intended to increase awareness and also increase the level of knowledge and skill among participants at Grazing BMP activities.

[2] The Grazing BMP program is an industry led self-assessment system used by graziers to benchmark their management practices against standards set by industry utilising best available science. Grazing BMP consists of five modules divided into key business areas: (1) Soil Health, (2) Grazing Land Management, (3) People and Business, (4) Animal Production, and (5) Animal Health and Welfare. For more information see: https://www.bmpgrazing.com.au/

	• Follow up services are to be provided to support Grazing BMP module completion. • Grazing BMP database reports will be used to track the number of modules attempted and completed, below, at and above standards, and the number of hectares covered. • Recent DAF8 activities, undertaken between October 2019 and March 2020, include: o 32 industry events across the south, central and north regions including 466 attendees (322 graziers from 208 businesses). o Main events included: (i) “Restarting, after good rain” - the GrazingFutures Echo Hills Walk-Over-Weighing project, (ii) The presentation of pasture recovery options to the Desert Uplands Committee, (iii) GrazingFutures staff assisting with the Westech ‘Paddock to Plate’ Steer Challenge, and (iv) Producer innovation hub meetings including the E-Beef and GrazingFutures themes of technologies, climate forecasting, pastures and business management. o One-on-one support to 92 livestock businesses in relation to seasonal forecasting, drought feeding, phosphorus supplementation, pasture improvement options, hay production, woody weed control, poisonous plants, property mapping, breeder-weaner management, sheep disease, interpreting soil-water analyses, wet season spelling options, and financial-livestock recording systems. o 108 professional development opportunities and project communication outputs including staff networking, extension-technical training, administration-project management skills, event evaluation data collection procedures, eBulletin-newsletter articles, project narratives/case studies, videos, social media posts and podcasts. o The project team partnered with Bush Agribusiness to deliver a general pest management principles workshop. o A number of property visits were conducted to expand grazier networks and district familiarisation. o In collaboration with AgForce, nine videos were developed featuring local producers sharing their strategies for drought preparation and management. The videos were shared on Facebook by AgForce and LeadingSheep and have been listed on the FutureBeef website. o Four tutorial videos also were created that covered key nutrition and costing tools on the FutureBeef website. o Breeder management workshops were conducted in three locations across the south region. A total of 32 participants from 23 grazing businesses attended. o Prior to the 2019/20 wet season, a Phosphorus Roadshow was organised, in collaboration with Tim Schatz of the Northern Territory (NT) Department of Primary Industries and Robert Dixon (QLD Alliance for Agriculture and Food Innovation). The Roadshow travelled from Georgetown to Burketown and brought producers together on property to discuss the benefits of feeding wet season Phosphorus in acutely deficient country.

	o Three Land Restoration Fund days were held in Normanton, Cloncurry, and Richmond. o The project team formed the GrazingFutures Northern Grazing Network (GFNGN) of producers in the north region to build viable and resilient businesses through training, coaching, travel and peer networking. The GFNGN currently includes 14 producers from five Northern Gulf businesses. • The DAF8 project is collaborating with the four-year E-Beef Smart Farm in Northern QLD project (a collaboration between Southern Gulf Natural Resource Management (NRM) group, Northern Gulf NRM group, Desert Channels QLD Inc., and DAF). • Up to 47 web pages with close links to drought management across the FutureBeef (NT and QLD) and DAF websites will be reviewed. • The DAF8 project team also will partner with DAF staff across QLD to review the ‘Dry season management of beef business’ manual. • A total of 27 narratives and 24 case studies will be produced by March 2020. • Further, the Royal Flying Doctor Service (RFDS) are supporting the project through Mental Health First Aid follow up sessions to work through real life scenarios staff often face in rural communities and with grazing families.
Outputs	Between 2017 and 2019, the GrazingFutures project has: • Delivered over 190 grazing industry training events and activities attended by 2,144 producers. • Provided one-on-one support to 71 QLD businesses. • Collaborated with other government agencies, NRM bodies, agribusinesses and tertiary agricultural students. • Partnered with Southern Gulf NRM, Northern Gulf and Desert Channels Qld to successfully receive one of only 15 Smart Farming Partnerships grants under the 2017-18 program. The successful project (*e-beef smart farming in Northern Queensland: implementing grazing best management practice through demonstrating how timely management decisions enhance pastures, groundcover, soils, land condition, business profitability and adaptability*) has leveraged an additional $4 million in funding for DCAP over 4 years by providing on-ground GrazingFutures demonstration sites and grazier action-learning groups. • Partnered with USQ to create linkages between GrazingFutures and the USQ Climate Mates program. • Project evaluation surveys indicate that 590 businesses intend to implement practice change and 161 businesses have already implemented changes. • Assisted with the response to the 2018/19 February monsoonal flood emergency through phone surveys of 243 properties across Cloncurry, Richmond, McKinlay, Hughenden and Winton Shires to assess safety, wellbeing, damage and needs. Staff from Longreach relocated to Winton to support the Shire’s response, and Charleville staff travelled to provide on-ground assistance and remote support. Beef and sheep staff from other centres also travelled to provide direct support, and remote support from their usual base of operations. Staff collaborated with Biosecurity Officers, local government, other QLD agencies and the Australian Defence Force. • 155 businesses have completed at least one module of Grazing BMP (whole of project target of 385).

	• Specific training for DAF8 team members and partners has included: FORAGE training; Franklin Covey training; the Rangelands Conference; herd, flock and equine nutrition; land condition and monitoring; grazing management and stocking rates; Reef extension approaches; decision making; Lamb Ex; Australian Mental Health First Aid; and training to become an EDGE (nutrition and grazing land management) deliverer. • The project has developed 22 narratives and six case studies as resources to support drought resilience extension activities. • The project has worked with over 70 different collaborators. The project team, partners and collaborators across 47 organisations have contributed to deliver 186 DAF8 project activities to support graziers to build drought and business resilience. • Continuously collaborated with the DCAP Phase 2 DES1, DES3, USQ4, DAF6 and DAF9 project teams.
Outcomes	• Evaluation surveys of GrazingFutures' event participants indicated that graziers have made changes to their animal production (49% of participants) and their grazing land management (18% of participants). Further, when asked to score their level of confidence in the GrazingFutures delivery team, 82% of graziers rated them at 6 or 7 on the 7-point scale. • The DAF8 investment has increased awareness and use of the Grazing BMP guidelines throughout south, central and north regions of western QLD. • Grazing businesses in western QLD have improved, and continue to improve, on-farm practices to manage, and recover from, drought, and improve preparedness for future drought events. • The project has resulted in ongoing and growing use of producer and NRM group networks to support extension activities as well as training and development of graziers, agricultural advisors and extension officers around western QLD. • There also has been increased awareness of, and support for, mental health first aid for extension officers and land managers facing drought through continued collaboration with the RFDS. • It is likely that much of the information and other outputs produced by the project also will be useful to graziers in other regions of QLD and northern Australia, particularly through access to online resources (Neil Cliffe, pers. comm., 2020).
Impacts	• Increased average, annual productivity and profitability for some graziers in QLD, particularly in western QLD, through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience. • Reduced variability of net farm incomes through improved farm management and decision making. • Some contribution to improved environmental outcomes through increased awareness of environmental management issues and producers making timely pasture management decisions. • Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) for the DCAP DAF8 project funded by DAF.

Table 2: Annual Investment in DCAP Project DAF8 (nominal $)

Contributor	2017/18	2018/19	2019/20	2020/21	Totals
DCAP (DAF) (cash)	1,000,000	1,000,000	1,000,000	1,000,000	4,000,000
Other Partners (in-kind)	420,000	440,000	470,000	470,000	1,800,000
Totals ($)	**1,420,000**	**1,440,000**	**1,470,000**	**1,470,000**	**5,800,000**

Source: Joe Rolfe (Project Leader), pers. comm., 2020.

Program Management Costs

For all financial contributions including in-kind, any management and administration costs for the project are assumed already built into the nominal dollar amounts appearing in Table 2.

Real Investment, Commercialisation and Extension Costs

No additional costs of extension were included as the project was extension based and encompassed a range of communication and extension components.

Other Potential Costs

There are likely to be costs associated with the contribution of non-DAF personnel (e.g. producers, external advisers, other DAF staff, etc.) attending the DCAP DAF8 events/activities. However, to include accurate costs would require a full set of data on the number and type of events, how long the events ran for, the number of attendees, how far they travelled, and what they would have been doing had they not attended the DCAP event. Such detailed data were not readily available at the time of the current analysis and thus have not been included in the CBA and the total present value of costs (PVC) estimated may be an underestimate of the total costs for the DAF8 investment.

5. Impacts

The principal impacts from the DAF8 project investment were identified as:

- Increased average, annual productivity and profitability for some graziers in QLD, particularly in western QLD, through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience.
- Some contribution to improved environmental outcomes through increased awareness of environmental management issues and producers making timely pasture management decisions.
- Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD).
- Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry.
- Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Table 3 provides a summary of the types of impacts identified, categorised into economic, environmental and social impacts.

Table 3: Triple Bottom Line Categories of Expected Impacts from Investment in DAF8

Economic	• Increased average, annual productivity and profitability for some graziers in western QLD through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience. • Reduced variability of net farm incomes through improved farm management and decision making.
Environmental	• Some contribution to improved environmental outcomes through increased awareness of environmental management issues and producers making timely pasture management decisions.
Social	• Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD). • Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry. • Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

Public versus Private Impacts

The primary impacts identified in this evaluation were industry related and therefore the benefits are considered private benefits. Private benefits are likely to accrue to beef and sheep producers (graziers) in Western QLD through increased profitability/ productivity and/or maintained social licence to operate.

Some public benefits also may be delivered in the form of improved environmental outcomes from improved grazing practices and the social benefits of increased industry capacity/ resilience and regional community spill-overs.

Distribution of Private Impacts

The primary beneficiaries of the DCAP DAF8 investment are graziers (beef and sheep) in Western QLD. Over time, it can be assumed that the benefits from the investment will be distributed between participants along commercial grazing supply chains according to relevant supply and demand elasticities.

Impacts on other Australian industries

The outputs of the DAF8 investment are likely to be relevant to beef and sheep grazing enterprises across QLD and northern Australia and also potentially to other grazing industries. Thus, it is possible that there may be impacts for other grazing primary industries and/or other regions in Australia.

Impacts Overseas

No significant impacts to overseas parties were identified. However, the sharing of important project outputs, such as BMPs for grazing industries dealing with climate variability and/or drought, may have some impact on grazing industries in other countries.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, RD&E priorities are reproduced in Table 4. The DAF 8 investment has contributed primarily to Rural RD&E Priority 4, with some contribution to Priority 3, and to Science and Research Priority 1, with some contribution to Priority 2.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[(a)] (est. 2015)	**Science and Research Priorities[(b)] (est. 2015)**
1) Advanced technology 2) Biosecurity 3) Soil, water and managing natural resources 4) Adoption of R&D	1) Food 2) Soil and Water 3) Transport 4) Cybersecurity 5) Energy and Resources 6) Manufacturing 7) Environmental Change 8) Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The Queensland Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: Queensland Government Research Priorities

Queensland Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1) Delivering productivity growth 2) Growing knowledge intensive services 3) Protecting biodiversity and heritage, both marine and terrestrial 4) Cleaner and renewable energy technologies 5) Ensuring sustainability of physical and especially digital infrastructure critical for research 6) Building resilience and managing climate risk 7) Supporting the translation of health and biotechnology research 8) Improving health data management and services delivery 9) Ensuring sustainable water use and delivering quality water and water security 10) The development and application of digitally-enabled technologies.	1) Real Future Impact 2) External Commitment 3) Distinctive Angle 4) Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

The DAF8 project addressed Queensland Science and Research Priorities 1 and 6, with some contribution to Priority 3. In terms of the guides to investment, the investment is likely to have real future impact through improved profitability and/or productivity of QLD grazing enterprises. Further, the DAF8 investment has been supported by a range of partners external to DAF and has provided resources, along with other DCAP Phase 2 investments, that have contributed to the critical mass for QLD grazing extension services to enable industry resilience.

6. Valuation of Impacts

Impacts Valued

Analyses were undertaken for total impacts that included future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of investment criteria.

Two primary impacts of the DCAP DAF8 investment were valued in monetary terms:

- Increased average, annual productivity and profitability for some graziers in QLD, particularly in western QLD, through improved management decisions driven by increased skills and knowledge of best practice and strategies for drought resilience.
- Maintained or enhanced social licence to operate for some grazing enterprises (particularly beef and sheep enterprises in western QLD).

The DAF8 project evaluation forms part of a broader assessment of the DCAP Phase 2 investment. The two impacts identified above were valued at a DCAP Program level. Six DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9) contributed to the two impacts. The estimated benefits then were shared between the six contributing DCAP projects.

Valuation of such shared impacts was restricted to the QLD beef industry. This was because:

i. Though some benefits from the six contributing projects would accrue to graziers in the NT and the north of Western Australia (WA), the main emphasis of the DCAP projects was in QLD,
ii. The QLD beef industry was made up of approximately 11.2 million head of cattle in 2018/19 comprising 49.8% of the national heard of 22.4 million head (ABS, 2020a). On the other hand, the QLD sheep industry is relatively small, making up only 3.1% of the national flock at approximately 2.2 million head (MLA pers. comm., based on ABS data, 2020), and
iii. The scope of the DCAP Program evaluation (assessment across nine DCAP Phase 2 project investments) meant that time and resources were necessarily limited.

Impacts Not Valued

Not all impacts identified in Table 3 could be valued in the assessment. Environmental and social impacts are difficult to value and may involve the application of non-market valuation techniques that were beyond the scope of the current assessment. Impacts were not valued due primarily to:

- A lack of evidence and/or data on which to base credible assumptions,
- The complexity of assigning monetary values to the impact (e.g. capacity built),
- Uncertainty regarding the pathways to impact, and
- The relative importance of the impact compared to the primary impact(s) valued.

The following impacts were not valued in the current analysis:

- Some contribution to improved environmental outcomes through increased awareness of environmental management issues and producers making timely pasture management decisions.
- Increased regional community wellbeing through spill-over benefits from a more productive and profitable grazing industry.

- Increased industry capacity to prepare for, respond to, and recover from drought and future climate variability (increased industry resilience).

A qualitative description of the impacts not valued and the reasons for not valuing them are provided below.

Contribution to improved environmental outcomes

Increased adoption of, and more effective implementation of, grazing BMPs and other improved farm practices (animal and/or land management) by QLD grazing enterprises may lead to improved environmental outcomes (such as reduced erosion or improved native vegetation and biodiversity).

Difficulties exist in identifying the specific environmental changes that may occur and then quantifying the value of such environmental benefits and linking the investments in the analysis to such impacts.

Increased regional community well-being

Regional communities linked to the Western QLD grazing industry are likely to benefit from increased industry profitability and/or productivity. However, such spill-over benefits, such as increased economic activity and employment along the product supply chain, would be difficult to value, given the number and spread of production systems, subregions, and the availability of time and resources for valuation.

Increased industry capacity

The DAF8 investment supported a significant number of workshops, field days, publications and other extension activities and materials. The project outputs have likely contributed to an increase in capacity for QLD grazing industry stakeholders, particularly producers and advisors, to implement effective grazing practices and build more resilient farm businesses across western QLD.

It is difficult to quantify the magnitude of such capacity enhancement because the initial level of capacity was unknown and placing a monetary value on human capacity requires the application of non-market valuation techniques that were beyond the scope of the current impact assessment. Also, to some extent, the capacity enhancement has been reflected via the productivity and profitability, and the social licence valuations.

Valuation of Impact 1: Increased Profitability and/ or Productivity for the QLD Grazing Industry

The investment in DAF8, along with five other DCAP Phase 2 projects (DES1, DES3, USQ4, DAF6 and DAF9), was assumed to have contributed to an increase in average, annual net farm income for QLD beef enterprises. The impact was divided between two types of beneficiaries:

1. Producers that were already utilising grazing BMPs, climate forecasting, models and decision-support tools (DSTs) for farm decision making that now make improved decisions as a result of the DCAP Phase 2 investment (existing users), and
2. New QLD producers adopting the use of grazing BMPs, climate forecasting, models and DSTs for farm decision making to improve profitability and productivity.

DAF8 has contributed to this impact through its focus on increased adoption of grazing BMPs and other land and animal management best practice across grazing enterprises (for example, stocking rate management, record keeping and succession planning, pasture management, etc.).

Specific assumptions used in the valuation are detailed in Table 6.

Valuation of Impact 2: Maintained Social Licence to Operate for the QLD Grazing Industry

The investment in DAF8, as part of the DCAP Phase 2 Program, has contributed to QLD beef producers (particularly in western QLD) adopting and/or improving on-farm animal and land management practices that, in turn, improve farmers' ability to respond to climate variability and drought, and potentially lead to improved environmental outcomes such as reduced erosion or improved native vegetation and biodiversity. Environmentally sensitive and responsive farm management was assumed to contribute to the maintenance or enhancement of the QLD grazing industry's social licence to operate.

Specific assumptions used in the valuation are detailed in Table 6.

Summary of Assumptions

A summary of the key assumptions made for the valuation of impacts is shown in Table 6.

Table 6: Summary of Assumptions

Variable	Assumption	Source
IMPACT 1: Increased Profitability and/ or Productivity for the QLD Grazing Industry		
Without DCAP Phase 2 Investment		
Average farm cash income for QLD beef producers	$163,645 per farm	5yr average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 2020a).
Average number of beef cattle enterprises in QLD	7,069	5yr average based on AgSurf population data for QLD beef (2015 to 2019) (ABARES, 2020a).
Current proportion of primary producers in QLD utilising climate forecasting, models, DSTs etc. for farm decision making	40%	Seasonal climate forecasts are used by 30 to 50% of agricultural producers in decision-making (Keogh et al., 2005; Keogh et al., 2004; Australian Government Department of Agriculture Fisheries and Forestry, 2004). The uptake of Seasonal Climate Forecasting (SCF) by agricultural producers in decision-making range from 30 to 50% (Cobon et al. 2017).
With DCAP Phase 2 Investment		

Part 1 (existing users): Proportion of existing users (primary producers) of climate forecasting, models, DSTs who have improved their decision making specifically due to DCAP Phase 2 investment	10%	¼ of existing users in QLD, conservative analyst assumption
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, DSTs etc.	5%	Conservative estimate based on a minimum profitability/ productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Part 2 (new users): Proportion of new QLD producers adopting the use of climate forecasting, models, DSTs etc. to improve on-farm decision making	20%	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).
Part 2 (new users): Attribution of practice change to DCAP2 investment for new users	50%	Acknowledges contribution of other drought resilience investments and previous investment in DCAP1.
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, DSTs etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown

		et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact	2024/25	Five years from first year of impact.
IMPACT 2: Maintained Social Licence to Operate for the QLD Grazing Industry		
Baseline data		
Average annual gross value of production (GVP) of QLD beef cattle	$5,206.2 million	5yr average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019)
With investment		
Profit as a proportion of GVP	10%	Agtrans Research, based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data 2017 to 2019) (ABARES, 2020b)
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment	10%	Analyst assumption.
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment	1.0%	Conservative estimate, analyst assumption (e.g. if current risk of loss of social licence is 5% p.a., this represents a reduction in risk to 4% p.a.).
First year of impact	2020/21	Third year of DCAP2 investments – allows time for outputs and extension to create practice change on farm.
Year of maximum impact	2024/25	Five years from first year of impact.
Risk factors (Impact 1 & 2)		
Probability of output	100%	Outputs have already been delivered.

Probability of outcome	100%	Already allowed for in the 10% of QLD beef enterprises at risk.
Probability of impact	80%	Analyst assumption – allows for exogenous factors that may affect realisation of impacts and also that the benefits estimated may not persist into the future
Other Factors (Impact 1 & 2)		
Attribution of benefits to the specific investment in DAF8 as part of the DCAP Phase 2 Program	16.9%	Based on the relative investment in DAF8 compared to the total investment across the six contributing projects (DES1, DES3, USQ4, DAF6, DAF8 and DAF9)
Additional costs	Based on the assumptions made, the benefits estimated were assumed to be NET of any additional adoption and/or implementation costs incurred by producers	

Counterfactual

The counterfactual, or what would have happened in the absence of the DCAP Phase 2 investments, includes the scenario that some additional and improved adoption of grazing BMPs (animal and land management) would have occurred without the DAF8 investment, given the range of other investments by other organisations (e.g. USQ Climate Mate Program). This scenario is allowed for in the valuation by considering only the improvements (e.g. increased adoption leading to increased average net farm income) specifically attributable to the DCAP Phase 2 investment

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020b). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2020/21).

Investment Criteria

Table 7 and Table 8 show the investment criteria estimated for different periods of benefits for the total investment and the DCAP (DAF) investment respectively. The present value of benefits (PVB) attributable to DCAP investment only, shown in Table 8, has been estimated by multiplying the total PVB by the DCAP proportion of real investment (69.0%).

Table 7: Investment Criteria for Total Investment in DAF8

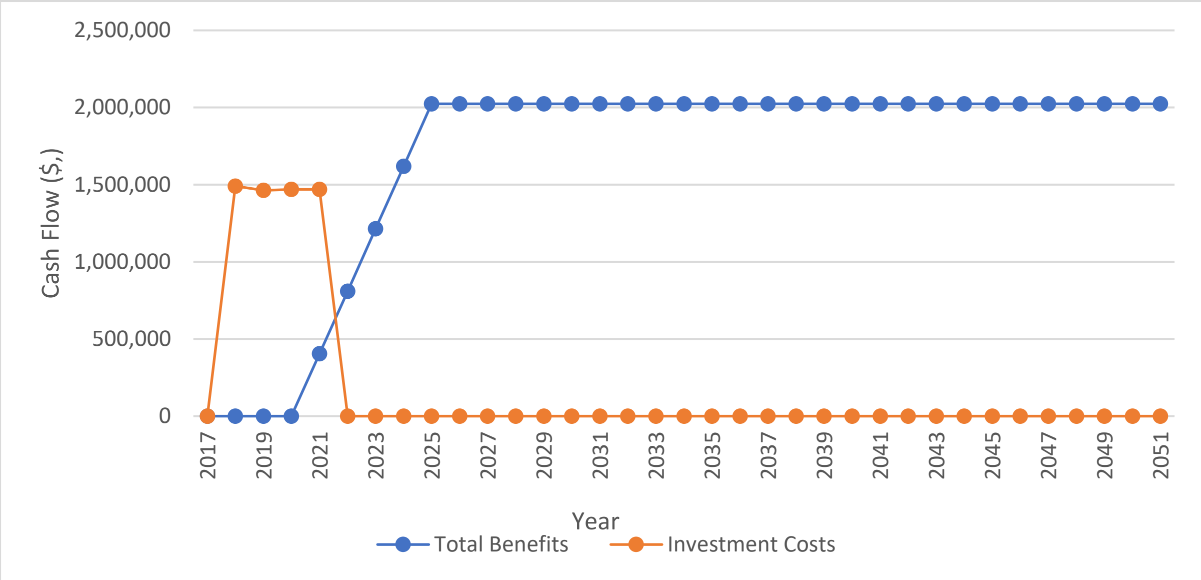
Investment criteria	**Number of years from year of last investment in the DCAP Phase 2 Program**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.39	6.60	13.14	18.26	22.27	25.42	27.88
Present value of costs ($m)	6.05	6.05	6.05	6.05	6.05	6.05	6.05
Net present value ($m)	-5.67	0.55	7.09	12.21	16.22	19.37	21.83
Benefit-cost ratio	0.06	1.09	2.17	3.02	3.68	4.20	4.61
Internal rate of return (%)	negative	6.95	17.88	20.29	21.02	21.27	21.36
MIRR (%)	negative	6.09	11.47	10.82	9.75	8.78	7.98

Table 8: Investment Criteria for DCAP (DAF) Investment in DAF8

Investment criteria	**Number of years from year of last investment in the DCAP Phase 2 Program**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.27	4.55	9.06	12.60	15.37	17.54	19.24
Present value of costs ($m)	4.18	4.18	4.18	4.18	4.18	4.18	4.18
Net present value ($m)	-3.91	0.37	4.88	8.42	11.19	13.36	15.06
Benefit-cost ratio	0.06	1.09	2.17	3.02	3.68	4.20	4.60
Internal rate of return (%)	negative	6.93	17.83	20.24	20.98	21.22	21.31
MIRR (%)	negative	6.07	11.46	10.82	9.74	8.78	7.98

The annual undiscounted benefit and cost cash flows for the DAF8 total investment for the duration of investment period plus 30 years from the last year of investment in the DCAP Phase 2 Program (2021/22) are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Gross Benefits and Total Investment Costs



Source of Benefits

Estimates of the relative contribution of each benefit valued, given the assumptions made, are shown in Table 9. It should be noted that approximately 96.5% of the total benefits estimated was derived from increased average, annual net farm income because of increased adoption of, or improved implementation of, grazing BMPs, climate forecasts, models and DSTs.

Table 9: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Impact 1: Increased profitability/ productivity for QLD beef enterprises	26.91	96.5
Impact 2: Maintenance of social licence for QLD beef enterprises	0.97	3.5
Total	27.88	100.0

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 10 presents the results that showed a moderate sensitivity to the discount rate. This was due largely to the fact that the benefit cash flows occur well into the future and therefore are subjected to more significant discounting effects.

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

Investment Criteria	Discount rate		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	58.69	27.88	15.82
Present value of costs ($m)	5.89	6.05	6.22
Net present value ($m)	52.80	21.83	9.60
Benefit-cost ratio	9.96	4.61	2.54

Other sensitivity analyses were carried out and reported at the DCAP Program level due to the valuation frameworks being extended to cover multiple DCAP Phase 2 projects. This was driven by the pathways to impact being common to each of the three impacts.

Confidence Ratings 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 impacts valued. Where there are multiple types of impacts it is often not possible to quantify all impacts 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 11). 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 11: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

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

Confidence in assumptions for the valuation also was rated as Medium. This was because of the fact that, though many of the assumptions were based on credible data and published literature, there has been little evidence of impacts to date as the DCAP Phase 2 investments are ongoing. Further, the DCAP Program evaluation necessitated valuation of some impacts at a broader level, and thus some of the assumptions were somewhat uncertain.

8. Conclusions

The investment in the DAF8 GrazingFutures project over the years ending June 2018 to June 2021 is likely to be successful and is on track to provide impacts for Western QLD graziers, the environment and the Australian and QLD government.

The principal benefits delivered by the project will accrue to beef and sheep producers in Western QLD from improved on-farm decision making and avoidance of some potential loss in social licence to operate. Some of these benefits are likely to be shared along the product supply chain due to increased economic activity (e.g. in product transporting and processing). Some public benefits may also be delivered via increased industry and community resilience and community spill-overs from increased, or at least maintained, producer incomes.

The total investment in the project of $6.05 million (present value terms) has been estimated to produce total gross benefits of $27.88 million (present value terms) providing a net present value of $21.83 million, a benefit-cost ratio of 4.61 to 1 (using a 5% discount rate over 30 years), an internal rate of return of 21.4% and a modified internal rate of return of 8.0%. Despite the fact that the PVC may have been underestimated since some potential costs were not able to be included in the analysis (e.g. costs associated with non-DAF personnel attending DCAP DAF8 events/activities), based on the conservative assumptions made and the fact that a number of benefits were identified but not valued, the investment criteria reported are likely to be an underestimate of the true performance of the DAF8 investment as several impacts identified were not valued in monetary terms.

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Appendix 9: An Impact Assessment of ‘Forewarned is Forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events’ (Project DAF9)

Final Report

To

The Department of Agriculture and Fisheries Queensland

By

Agtrans Research

in conjunction with AgEconPlus

August 2020

Contents

List of Tables and Figures

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Abbreviations

BCR	Benefit-Cost Ratio
BoM	Bureau of Meteorology
CBA	Cost-Benefit Analysis
DAF	Department of Agriculture and Fisheries – Queensland
DCAP	Drought and Climate Adaptation Program
FWFA	Forewarned is Forearmed project
GDP	Gross Domestic Product
GVP	Gross Value of Production
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
PVB	Present Value of Benefits
PVC	Present Value of Costs
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RRD4P	Rural R&D for Profit program (Australian Government)
NSW	New South Wales
USQ	University of Southern Queensland

Glossary of Economic Terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	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.
Internal Rate of Return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits is equal to 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 (MIRR)	The MIRR is a modified IRR estimated so that any cash inflows from an investment are re-invested at the rate of the cost of capital (a designated re-investment rate).
Net Present Value (NPV)	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 (PVB)	The discounted value of benefits.
Present Value of Costs (PVC)	The discounted value of investment costs.

Executive Summary

This report presents the results of an impact assessment of a still current project investment (DAF9, *Forewarned is forearmed: Equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events*) within Phase Two of the Queensland Drought and Climate Adaptation Program (DCAP).

The project is described qualitatively using a logical framework that includes project objectives, activities and outputs to date, and prospective outcomes and impacts. Potential impacts are categorised into a triple bottom line framework. Principal potential impacts are then estimated in dollar terms.

Potential benefits are estimated for a range of time frames up to 30 years from the last year of investment in the project (2020/21). Past and future cash flows in 2019/20 dollar terms are discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria.

The cost-benefit analysis (CBA) has been conducted according to the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The investment in DAF9 will deliver first ever forecasts of extreme weather/climate events weeks and up to a season in advance and will equip farmers with the information and tools to be forewarned and prepared. The project is expected to increase annual average productivity and profitability for some sugar and northern beef producers through improved management decisions. Use of the DAF9 products is expected to provide additional protection for the growing and grazing resource and protect primary producer social licence to operate.

In summary, the total investment in the project of $3.26 million (present value terms) has been estimated to produce total gross benefits of $24.95 million (present value terms) providing a net present value of $21.69 million, a benefit-cost ratio of 7.66 to 1 (using a 5% discount rate), an internal rate of return of 31.2% and a modified internal rate of return of 12.2%.

The investment criteria reported are likely to have somewhat undervalued the full set of impacts delivered by the investment. This was because a number of the benefits identified were not valued. For reasons explained in the assessment, benefits accruing to reduced income variability, impacts on other industries, capacity built and regional spillovers, were not valued.

1. Evaluation Methods

The evaluation approach follows general evaluation guidelines that now are 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. This impact assessment uses Cost-Benefit Analysis (CBA) as its principal tool. The approach includes both qualitative and quantitative descriptions that are in accord with the Impact Assessment Guidelines of the Council of Rural Research and Development Corporations (CRRDC) (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs to date, and actual and potential outcomes and impacts. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, or the limited time and resources available to the evaluation. The potential impacts valued are still deemed to represent the principal benefits delivered by the project investment.

2. Background & Rationale

Background

Australian farmers operate in one of the most variable climates in the world, with extreme events and climate variability the largest drivers of fluctuations in annual agricultural income and production. The Forewarned is Forearmed (FWFA) project funded under round three of the Australian Government's Rural Research and Development for Profit (RRD4P) program is a five year, $14.6 million investment. Partners include the Bureau of Meteorology (BoM), eight rural Research and Development Corporations and three Australian universities. There are nine partner industries in the project. The project is made up of four linked work programs: 1) understand industry needs and improve forecasts, 2) develop extreme event forecast products, 3) industry risk management, and 4) extension and communication.

Rationale for the investment

It is anticipated that the project will deliver direct value to farmers through provision of first ever forecasts of extreme weather/climate events weeks and up to a season in advance and equip farmers with the information and tools to be forewarned and prepared. The University of Southern Queensland (USQ), is a lead partner in work programs 3 and 4 and will identify extreme event risks, response scenarios for risks and provide feedback to BoM on forecast products produced for the sugar and northern red meat industries.

3. Project Details & Logical Framework

The project is described in a logical framework in Table 1.

Table 1: Project Logical Framework

Code and Title	DAF9: Forewarned is Forearmed: equipping farmers and agricultural value chains to proactively manage the impacts of extreme climate events'.
Project Details	Organisation: USQ. Period: July 2017 to June 2022. Principal Investigator: Roger Stone.
Objectives	1. Trial new BoM extreme event forecast products and determine their usefulness to sugar and northern Australian red meat producers. 2. Prepare sugar and northern red meat climate risk management plans. 3. Increase the awareness and use of extreme event forecasts and climate risk management plans.
Activities and Outputs	• Establish farmer and farm advisor reference groups for the sugar and northern red meat industries. Three Industry Reference Groups established for beef (Charters Towers, Longreach, and Rockhampton) and one for sugar. In 2019, 'roadshow' meetings attracted 23 primary producers. • Identify key extreme events of consequence and evaluate associated response scenarios for the sugar and northern red meat industries. Events identified focussed on extremes of heat, wet and dry for the sugar industry and extreme heat, cold, wet and dry for the northern red meat industry. • Collect and evaluate feedback on the products and tools produced by BoM. Primary producers from both industries saw real value in the first set of extreme heat forecasts produced in 2019 and expressed a preference for visual information in the form of pie charts and quintile bars. • Communicate the availability of FWFA products to the sugar and northern red meat industries using existing extension channels e.g. 'The Break', Grazing Best Management Practice and Future Profit.
Outcomes (potential)	• Farmers in the sugar and northern red meat industries (northern beef) are proactively managing for extreme weather/climate events using FWFA seasonal forecasts and risk management plans.
Impacts (potential)	• Economic – increased annual average productivity and profitability for some sugar and northern beef producers through improved management decisions. • Economic – reduced variability of annual net income for some sugar and northern beef producers. • Economic – positive impacts on the profitability of other agricultural industries (e.g. horticulture) and sectors of the Australian economy (e.g. building industry, disaster management). • Economic – positive impacts on the profitability of agricultural supply and service industries with improved capacity to forecast seasonal demand. • Environmental – additional protection for the growing and grazing resource with, for example, earlier destocking decisions, resulting in an enhanced social licence to operate. • Environmental – implementation of nutrient management practices in coastal cropping systems which avoid nutrient and sediment losses through the use of extreme rainfall event forecasts. • Capacity – sugar and northern red meat producers with new skills in climate forecasting and in responding to forecast information.

	• Capacity – USQ and DAF researchers with new skills in climate forecasting and management response. • Social – contribution to improved regional community wellbeing from spill-over benefits from more profitable/less variable sugar and red meat production.

Note: DCAP Phase 2 projects were ongoing at the time of evaluation. Information was current as at 31 May 2020

4. Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) for the project with funding provided by DAF, USQ and the Australian Government funded RRD4P program.

Table 2: Annual Investment in the Project for Years Ending June 2018 to June 2022 (nominal $)

Contributor	2018	2019	2020	2021	2022	Total
DAF cash	40,000	40,000	40,000	40,000	40,000	200,000
DAF in-kind	110,000	110,000	110,000	110,000	110,000	550,000
USQ in-kind	163,600	175,100	193,900	205,000	216,700	954,300
RRD4P cash	285,000	291,050	306,950	312,000	317,350	1,512,350
Total	598,600	616,150	650,850	667,000	684,050	3,216,650

Source: USQ contractual agreement with MLA.

Program Management Costs

For all three investment partners, the management and administration costs for the project are already built into the nominal dollar amounts appearing in Table *2*.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019/20-dollar terms using the Implicit GDP Deflator index (ABS, 2020). Sugar and beef industry extension and communication costs were incorporated into the project budget.

5. Impacts

An overview of potential impacts in a triple bottom line categorisation is shown in Table 3.

Table 3: Categories of Impacts from the Investment

Economic	Environmental	Social
Increased annual average productivity and profitability for some sugar and northern beef producers through improved management decisions. Reduced variability of annual net income for some sugar and northern beef producers. Positive impacts on the profitability of other agricultural industries (e.g. horticulture) and sectors of the Australian economy (e.g. building industry, disaster management). Positive impacts on the profitability of agricultural supply and service industries with improved capacity to forecast seasonal demand.	Additional protection for the growing and grazing environment with, for example, earlier destocking decisions and resulting in an enhanced licence to operate. Implementation of nutrient management practices in coastal cropping systems which avoid nutrient and sediment losses through the use of extreme rainfall event forecasts.	Sugar and northern red meat producers with new skills in climate forecasting and in responding to forecast information. USQ and DAF researchers with new skills in climate forecasting and management response. Contribution to improved regional community wellbeing from spill-over benefits from more profitable/less variable sugar and red meat production.

Public versus Private Impacts

The impacts identified from the investment are mostly private in nature. Private impacts are likely to accrue to sugar, beef, and other primary producers in the form of increased enterprise profitability and retention of social licence to operate. Other sectors of the Australian economy may also benefit (e.g. the building industry). Potential public impacts include improved environmental outcomes, capacity building in research staff and producers, possible improvements in public services (e.g. disaster management) as well as community spill-over benefits associated with improved long-term productivity and profitability in the sugar, beef, and other primary industries.

Impacts Accruing to other Primary Industries

Impacts target sugar and northern beef production but project outputs (forecasts and risk management strategies) are relevant to other primary industries including QLD horticulture.

Distribution of Benefits along the Sugar and Northern Red Meat Supply Chains

Some of the potential impacts accruing to sugar and beef producers will be shared along the supply chain with mills, processors (abattoirs), wholesalers, exporters, retailers, and consumers.

Impacts Overseas

Forecasts and risk management plans are relevant to the Australian climate and agricultural production systems. Research results from this project will have limited relevance overseas.

Match with National and State Priorities

The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) Priorities are reproduced in Table 4. The investment in long term weather/climate forecasts and risk management strategies for sugar and northern beef is relevant to Rural RD&E Priority 1, 3 and 4 as well as to Science and Research Priority 1 and 7.

Table 4: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities[a] (est. 2015)	**Science and Research Priorities[b] (est. 2015)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health

(a) Source: Commonwealth of Australia (2015)
(b) Source: Office of the Chief Scientist (2015)

The QLD Government's Science and Research Priorities, together with the four decision rules for investment that guide evaluation, prioritisation and decision making around future investment are reproduced in Table 5.

Table 5: QLD Government Research Priorities

QLD Government	
Science and Research Priorities (est. 2015)	**Investment Decision Rule Guides (est. 2015)**
1. Delivering productivity growth 2. Growing knowledge intensive services 3. Protecting biodiversity and heritage, both marine and terrestrial 4. Cleaner and renewable energy technologies 5. Ensuring sustainability of physical and especially digital infrastructure critical for research 6. Building resilience and managing climate risk 7. Supporting the translation of health and biotechnology research 8. Improving health data management and services delivery 9. Ensuring sustainable water use and delivering quality water and water security 10. The development and application of digitally enabled technologies.	1. Real Future Impact 2. External Commitment 3. Distinctive Angle 4. Scaling towards Critical Mass

Source: Office of the Chief Scientist Queensland (2015)

The investment addressed QLD Science and Research Priorities 1 and 6. In terms of the guides to investment, the investment is likely to have a real future impact on sugar and beef production in QLD, and, through the Australian Government's RRD4P program, was well supported by others external to the QLD Government. It is anticipated that use of long-term weather/climate forecasts and risk management strategies will scale towards critical mass over time.

6. Valuation of Impacts

Impacts Valued in Monetary Terms
Analyses were undertaken for total impacts that included future expected impacts. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved.

After review of project reports four key impacts were quantified – increase in profitability for sugarcane producers, increase in profitability for northern beef producers, maintained social licence to operate for some QLD sugar growers and maintained social licence to operate for some QLD beef producers.

A summary of project assumptions and data source used to value impacts is provided in Table 6.

Table 6: Summary of Assumptions for Valuing Benefits

Variable	Assumption	Source
Impact 1: Increase in profitability for sugarcane growers		
Increase in sugarcane growing profitability with use of FWFA forecasts and risk management tools.	$0 to $347/ha/year (mid-point of $173.50/ha assumed)	Sugar Case Study – valuing seasonal climate forecasts in Australian agriculture (Darbyshire, et at 2108) https://www.dpi.nsw.gov.au/climate-and-emergencies/climate-and-weather/research/value-of-forecasts
Average area of production per farm.	140 ha	USQ DCAP Phase 2 Producing Enhanced Crop Insurance Systems Case Study.
Maximum number of QLD sugarcane growers using project outputs.	400	Analyst assumption – 10% of grower population. Peak industry body Canegrowers report that there are approximately 4,000 Australian growers. Sensitivity test completed at 5% and 20%.
Year in which project outputs are available to QLD sugarcane growers.	2020/21	Third year of DCAP projects. Some forecast tools and risk management strategies available.
Year of maximum impact.	2024/25	Five years from first year of impact.
Attribution of impacts to this project (DAF9).	30%.	Major investment in extreme event forecasts prepared by BoM using a separate and much larger project budget.
Impact 2: Increase in profitability for northern beef producers		
Average farm cash income for QLD beef producers.	$163,645 per farm.	5 year average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (ABARES, 2020).
Average number of beef cattle enterprises in QLD	7,069	5 year average based on AgSurf farm cash income data for QLD beef (2015 to 2019) (ABARES,

		2020). NB: estimate excludes mixed enterprises (beef + sheep).
Current proportion of primary producers in QLD utilising climate forecasting, models, decision support tools etc. for farm decision making	40% Midpoint of most recent estimate: Coban (2017)	Seasonal climate forecasts are used by 30 to 50% of agricultural producers in decision-making (Keogh et al., 2005; Keogh et al., 2004a; Australian Government Department of Agriculture Fisheries and Forestry, 2004). The uptake of SCF by agricultural producers in decision-making range from 30 to 50% (Cobon et al. 2017).
Part 1 (existing users): Proportion of existing users (primary producers) of climate forecasting, models, decision support tools who have improved their decision making specifically due to DCAP Phase 2 investment	25%	¼ of existing users in QLD, conservative analyst assumption
Part 1 (existing users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	5%	Conservative estimate based on a minimum profitability/ productivity improvement of 10% for new adopters. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Part 2 (new users): Proportion QLD producers newly adopting the use of climate forecasting, models, decision support tools etc. to improve on-farm decision making	15% (increasing proportion of total QLD users from 40% to 55%)	Given a base assumption of 40% of producers currently using climate forecasting etc. (see above), this is a conservative assumption supported by evidence that in regions with access to local champions and specialists in seasonal climate systems, adoption of seasonal forecasts into management decisions is increased to 75% (Cobon et al. 2008; Cliffe et al. 2016).

Part 2 (new users): Attribution of practice change to DCAP2 investment for new users	50%	Acknowledges contribution of other drought resilience investments and previous investment in DCAP1
Part 2 (new users): Increase in net farm cash income due to improved decisions for producers who were already utilising climate forecasting, models, decision support tools etc.	10%	Conservative estimate. Seasonal forecasts can increase productivity and profitability by 10-26% (Ash et al. 2000; McKeon et al. 2000; Stafford Smith et al. 2000; O'Reagain et al. 2011; Brown et al. 2017, Anh Vo et al 2017, Cobon et al 2020). These studies have shown that using the current SOI to adjust stock numbers can increase profit by 10% and a perfect forecast of pasture growth by 26% (Brown et al. 2017).
Year in which outputs are available to northern beef producers.	2020/21	Third year of DCAP projects. Some forecast tools and risk management strategies available.
Year of maximum impact.	2024/25	Five years from first year of impact.
Specific attribution to this project (DAF9).	9.3%.	Increase in profitability for Northern Beef Producers assessed across 6 DCAP projects contributing to this impact and assigned to individual projects using a relative cost contribution approach. Six DCAP projects were DES1, DES3, USQ4, DAF6, DAF8 and DAF9.
Impact 3: Maintained social licence to operate for some QLD sugar growers		
Average annual gross value of production (GVP) of QLD sugarcane.	$1,242 million	5 year average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019).
Profit as a proportion of GVP.	10%	Analyst assumption based on the long term average profit for mature agricultural commodities being between 5% and 15%.
Proportion of QLD sugar industry at risk of loss of profitability without DCAP2 investment.	10%	Analyst assumption. NB: Sensitivity test completed at 5% and 20%.
Estimated reduction in risk of loss of social licence attributable to DCAP2 investment.	1%	Conservative estimate, analyst assumption.
Year in which outputs are available to QLD sugarcane growers.	2020/21	Third year of DCAP projects. Some forecast tools and risk management strategies available.
Year of maximum impact.	2024/25	Five years from first year of impact.

Attribution of impacts to this project (DAF9).	30%.	Major investment in extreme event forecasts prepared by BoM using a separate and much larger project budget.
Impact 4: Maintained social licence to operate for some QLD beef producers		
Average annual gross value of production (GVP) of QLD beef.	$5,206.2 million	5 year average based on ABS value of agricultural commodities data (2014 to 2018) (ABS, 2015 to 2019).
Profit as a proportion of GVP.	10%	Analyst assumption based on average profit as a proportion of total cash receipts for QLD beef producers (ABARES farm financial performance data 2017 to 2019) Australian Bureau of Agricultural and Resource Economics and Sciences, 2020.
Proportion of QLD beef industry at risk of loss of profitability without DCAP2 investment.	10%	Analyst assumption.
Change in risk attributable to DCAP2 investment.	1%	Conservative estimate, analyst assumption.
Year in which outputs are available to QLD beef producers.	2020/21	Third year of DCAP projects. Some forecast tools and risk management strategies available.
Year of maximum impact.	2024/25	Five years from first year of impact.
Specific attribution to this project (DAF9).	9.3%.	Increase in profitability for Northern Beef Producers assessed across 6 DCAP projects contributing to this impact and assigned to individual projects using a relative cost contribution approach. Six DCAP projects areDES1, DES3, USQ4, DAF6, DAF8 and DAF9.

Specific Impacts not Valued in Monetary Terms

The impacts identified but not valued included:

- The impact of reduced income variability was not valued as measures of the current level of income variability were not readily available; furthermore, it is difficult to convert any reduced variability into simple dollar terms without knowledge, for example, of interest rates that may apply to surplus investment in good years versus increased loans in poor years.
- Positive impacts on the profitability of other agricultural and non-agricultural sectors were not valued due to lack of information on the scale and timing of benefits.
- Increased producer and researcher capacity in relation to use of applied climate forecasts would be difficult to value. However, some of the new capacity built will be accounted for in the improved climate modelling and decision support tools already developed and valued in the existing analysis.
- The increased spillovers to regional communities from sustained or increased income and decreased income variability was not valued as any increased economic activity and employment along the product supply chain would be difficult to value, given the

number and spread of production systems, subregions, and the availability of time and resources for valuation.

Counterfactual
The counterfactual includes a scenario that some climate knowledge and seasonal forecasting tools would have been utilised by growers and graziers without the investment in DAF9. This scenario is allowed for in the valuation by considering only the improvements in such tools as well as their increased availability and promotion through DAF9 and its associated projects, including delivery projects.

7. Results

All past costs were expressed in 2019/20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (GDP) (ABS, 2020). All costs and benefits were discounted to 2019/20 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed (2051/52).

Investment Criteria

Tables 7 and 8 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 8, has been estimated by multiplying the total PVB by the DAF proportion of real investment (23.3%).

Table 7: Investment Criteria for Total RD&E Investment in the DAF9 DCAP Project

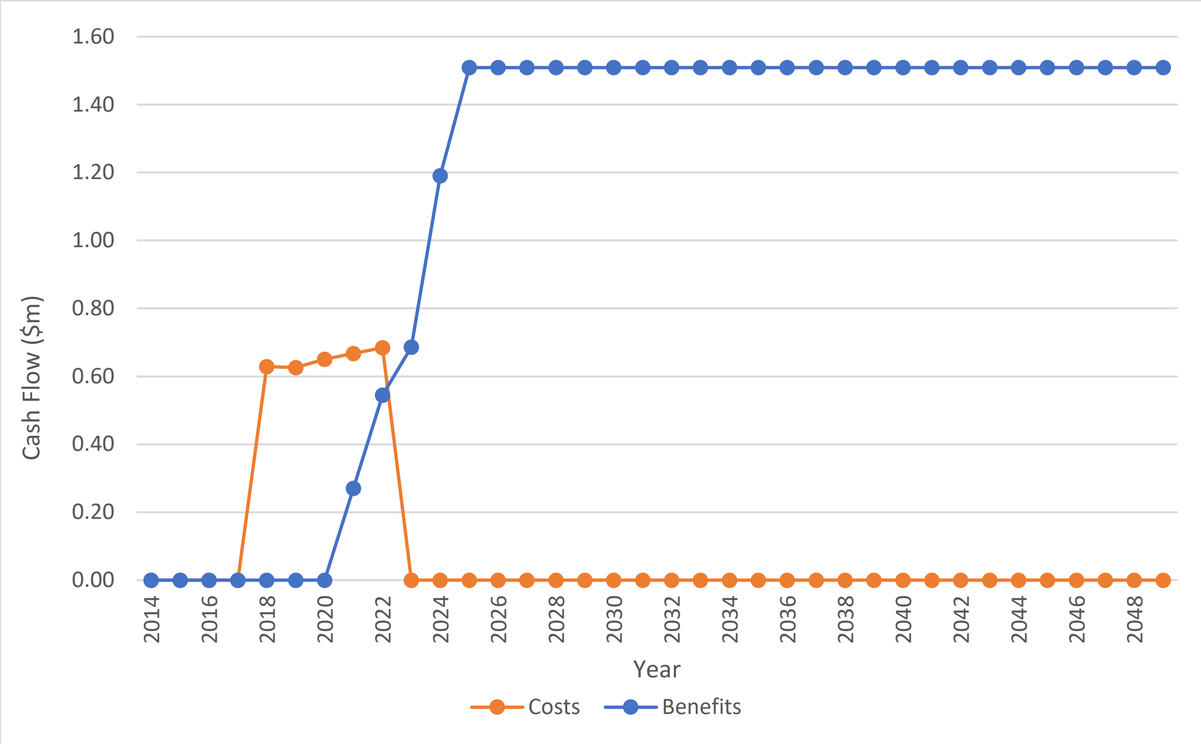
Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.85	6.92	12.46	16.80	20.20	22.86	24.95
Present value of costs ($m)	3.26	3.26	3.26	3.26	3.26	3.26	3.26
Net present value ($m)	-2.40	3.66	9.20	13.54	16.94	19.61	21.69
Benefit-cost ratio	0.26	2.12	3.82	5.16	6.20	7.02	7.66
Internal rate of return (IRR) (%)	negative	23.25	29.69	30.86	31.13	31.19	31.21
Modified IRR (%)	negative	15.18	16.62	15.42	14.13	13.04	12.15

Table 8: Investment Criteria for DAF RD&E Investment in the DAF9 DCAP Project

Investment criteria	**Number of years from year of last investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present value of benefits ($m)	0.20	1.61	2.91	3.92	4.71	5.34	5.82
Present value of costs ($m)	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Net present value ($m)	-0.56	0.85	2.14	3.16	3.95	4.57	5.06
Benefit-cost ratio	0.26	2.12	3.81	5.14	6.18	7.00	7.63
Internal rate of return (IRR) (%)	negative	22.87	29.28	30.47	30.74	30.81	30.83
Modified IRR	negative	15.12	16.58	15.39	14.11	13.03	12.13

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 1.

Figure 1: Annual Cash Flow of Undiscounted Total Net Benefits and Total RD&E Investment Costs



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

Table 9: Contribution to Total Benefits from Each Source

Source of Benefit	Contribution to PVB ($m)	Share of benefits (%)
Increase in profitability for sugarcane growers	7.96	31.9%
Increase in profitability for northern beef producers	15.10	60.5%
Maintained social licence to operate for some QLD sugar growers	1.35	5.4%
Maintained social licence to operate for some QLD beef producers	0.54	2.2%
Total	24.95	100.0%

Sensitivity Analyses
A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 10 shows that investment criteria are not overly sensitive to the discount rate and remain positive at a 10% discount rate, twice the rate of the base assessment.

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

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	53.76	24.95	13.96
Present value of costs ($m)	3.26	3.26	3.27
Net present value ($m)	50.50	21.69	10.68
Benefit-cost ratio	16.51	7.66	4.27

A sensitivity test was completed on the maximum number of QLD sugarcane growers adopting FWFA project outputs (Table 11). Results show that with a maximum of 800 growers adopting the BCR is greater than 10%.

Table 11: Sensitivity to QLD Sugarcane Growers Adopting FWFA Project Outputs
(Total investment, 30 years)

Investment Criteria	Maximum QLD Canegrower Adoption		
	200 growers i.e. 5%	400 growers ie.10% (base)	800 growers i.e. 20%
Present value of benefits ($m)	21.03	24.95	32.09
Present value of costs ($m)	3.26	3.26	3.26
Net present value ($m)	17.78	21.69	28.84
Benefit-cost ratio	6.46	7.66	9.85

A final sensitivity test was completed on the proportion of QLD sugar industry at risk of loss of social licence and profitability without DCAP2 investment (Table 12). Results show that analysis results are not sensitive to this assumption.

Table 12: Sensitivity to Share of QLD Sugarcane Industry at Risk of Social Licence/Profit Loss, No DCAP2
(Total investment, 30 years)

Investment Criteria	Share QLD Sugarcane Industry at Risk of Social Licence/Profit Loss		
	5%	10% (base)	20%
Present value of benefits ($m)	24.28	24.95	26.31
Present value of costs ($m)	3.26	3.26	3.26
Net present value ($m)	21.02	21.69	23.05
Benefit-cost ratio	7.45	7.66	8.08

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 12). The rating categories used are High, Medium, and Low, where:

High:	denotes a good coverage of benefits or reasonable confidence in the assumptions made
Medium:	denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
Low:	denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 13: Confidence in Analysis of Project

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

Coverage of benefits was assessed as Medium-High. While there were a number of benefits identified but not valued, the principal economic impacts delivered by the project (increase in average net sugarcane grower and beef producer income and protection of the social licence for sugarcane growers and beef producers) were quantified.

Confidence in assumptions was rated as Medium as some of the assumptions associated with the increased average income and the reduction in the social licence risk were somewhat uncertain.

8. Conclusion

The investment in DAF9 will deliver first ever forecasts of extreme weather/climate events weeks and up to a season in advance and will equip farmers with the information and tools to be forewarned and prepared. The project is expected to increase annual average productivity and profitability for some sugar and northern beef producers through improved management decisions. Use of the DAF9 products is expected to provide additional protection for the growing and grazing resource and protect primary producer social licence to operate.

In summary, the total investment in the project of $3.26 million (present value terms) has been estimated to produce total gross benefits of $24.95 million (present value terms) providing a net present value of $21.69 million, a benefit-cost ratio of 7.66 to 1 (using a 5% discount rate), an internal rate of return of 31.2% and a modified internal rate of return of 12.2%.

The investment criteria reported are likely to have somewhat undervalued the full set of impacts delivered by the investment. This was because a number of the benefits identified were not valued. For reasons explained in the assessment, benefits accruing to reduced income variability, impacts on other industries, capacity built and regional spillovers, were not valued.

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