Final Report

Project title:

Horticulture Impact Assessment Program:

Appendix 13: Adoption of precision systems technology in vegetable production (VG16009 Impact Assessment)

Impact analyst:

Peter Chudleigh

Delivery partner:

AgEconPlus and Agtrans Research

Project code:

MT18011

Date:

31 August 2021

Disclaimer:

Funding statement:

This project has been funded by Hort Innovation, using the research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Publishing details:

Published and distributed by: Hort Innovation

Level 7/141 Walker St,
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

Contents

Contents	3
Tables	4
Figures	4
Executive Summary	5
Keywords	5
Introduction	6
General Method	7
Background & Rationale	8
Project Details	9
Project Investment	14
Impacts	15
Valuation of Impacts	17
Results	19
Conclusion	22
Glossary of Economic Terms	23
Acknowledgements	25
Abbreviations	25

Tables

Table 1: Statistics for Australian Vegetable Production 2018-2020 8
Table 2: Logical Framework for Project VG16009 9
Table 3: Annual Investment in Project VG16009 (nominal $) 14
Table 4: Triple Bottom Line Categories of Principal Impacts from Project VG16009 15
Table 5: Australian Government Research Priorities 16
Table 6: Summary of Assumptions for Impact of VG16009 18
Table 7: Investment Criteria for Total Investment in Project VG16009 19
Table 8: Investment Criteria for Hort Innovation Investment in Project VG16009 19
Table 9: Sensitivity to Discount Rate 20
Table 10: Sensitivity to Maximum Proportion of Vegetable Production in 10 Years 20
Table 11: Confidence in Analysis of Project 21

Figures

Figure 1: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs 20

Executive Summary

What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *Adoption of precision systems technology in vegetable production.* The project was funded by Hort Innovation over the period October 2016 to October 2019.

Methodology

The investment was first analysed qualitatively within a logical framework that included activities and outputs, outcomes, and impacts. Actual and/or potential impacts then were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation in monetary terms (quantitative assessment). Past and future cash flows were expressed in 2019/20 dollar terms and were discounted to the year 2019/20 using a discount rate of 5% to estimate the investment criteria and a 5% reinvestment rate to estimate the modified internal rate of return (MIRR).

Results/key findings

The investment in VG16009 has enhanced Australian vegetable industry awareness and adoption of the potential benefits of using precision systems technology. Further, the project investment has contributed to a higher level of awareness and knowledge about precision agriculture techniques that may be applied in future vegetable production in Australia. As a result, VG16009 is likely to have contributed to future gains in productivity and profitability by the Australian vegetable industry with some associated environmental benefits.

Investment Criteria

Total funding from all sources for the project was $6.00 million (present value terms). The investment was estimated to produced total expected benefits of $10.26 million (present value terms). This gave a net present value of $4.26 million, an estimated benefit-cost ratio of 1.7 to 1, an internal rate of return of 10.9% and a modified internal rate of return of 6.9%. The estimated benefits were driven by the single impact of the likely gain in profitability of the future use of PA in the Australian vegetable industry, taking into account a number of risk factors and a potential counterfactual scenario addressing of what would have occurred without the investment.

Several environmental and social impacts were also identified but not valued as part of the current assessment. Given the impacts not valued, combined with conservative assumptions made for the principal economic impacts valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the VG16009 investment.

Conclusions

Project VG16009 has been a successful investment by Hort Innovation and DAF via its likely contribution to the future productivity and profitability for some Australian vegetable industries. These outcomes have been delivered via the involvement of vegetable growers, follow up projects, and a strong communication and extension investment.

Keywords

Impact assessment, cost-benefit analysis, VG16009, vegetables, precision agriculture

Introduction

Horticulture Innovation Australia Limited (Hort Innovation) required a series of impact assessments to be carried out annually on a number of investments in the Hort Innovation research, development and extension (RD&E) portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation's current Strategic Plan and the Evaluation Framework associated with Hort Innovation's Statutory Funding Agreement with the Commonwealth Government.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

Under the impact assessment program (Project MT18011) three series of impact assessments were conducted in calendar 2019, 2020 and 2021. Each included 15 randomly selected Hort Innovation RD&E investments (projects). The third series of impact assessments (current series) was selected from an overall population of 56 Hort Innovation investments worth an estimated $38.9 million (nominal Hort Innovation investment) where a final deliverable had been submitted in the 2019/20 financial year.

The 15 investments were selected through a stratified, random sampling process such that investments chosen represented at least 10% of the total Hort Innovation RD&E investment in the overall population (in nominal terms) and was representative of the Hort Innovation investment across six, pre-defined project size classes.

Project *VG16009: Adoption of precision systems technology in vegetable production* was randomly selected as one of the 15 investments under MT18011 and was analysed in this report.

General Method

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

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, outcomes, and actual and/or potential 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. Where impact valuation was exercised, the impact assessment used cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background & Rationale

Background

Effective use of precision systems technology in the vegetable industry can have multiple applications. Primarily precision agriculture provides a greater level of spatial information about a field or crop through a range of sensing and mapping technologies e.g. soil or crop sensing technologies. Precision agriculture approaches can also be used to direct in field activities e.g. crop scouting or sampling and include management options such as targeted application of crop inputs (e.g. fertiliser, soil amendments, irrigation) to segments of vegetable areas.

Total tonnages and values of vegetables produced in Australia are provided In Table 1. Vegetable production is carried out in all six Australian States, with negligible production in the Australian Capital Territory and the Northern Territory. The largest vegetable producing states in terms of production are Victoria and Queensland followed by South Australia, Tasmania, Western Australia and New South Wales.

However, the totals reported in Table 1 include vegetables that are not covered by the national vegetable levy, including potatoes, sweetpotatoes, onions, mushrooms, asparagus, and others (Adam Briggs, pers. comm., 2021).

Table 1: Statistics for Australian Vegetable Production 2018-2020

Year ended 30 June	2018	2019	2020	3-year Average
Total Aus. vegetable production (t)	3,696,393	3,723,512	3,723,506	3,714,470
Total value of Aus. vegetable production ($m)	4,346.9	4,724.3	4,851.3	4,640.8

Source: Hort Innovation (2020) Australian Horticultural Statistics Handbook

Rationale

Despite earlier desktop work on the application of precision agriculture (PA) for vegetables, there had been limited effort in the past on the development of precision or spatial technologies relevant to vegetable production in Australia. Apart from auto-steer (GPS guidance), examples of other potential opportunities included soil mapping, crop sensing, variable rate technologies and yield monitoring.

There had been a lack of regionally relevant case studies, demonstrations and support for vegetable producers and application developers. However, as the cost of relevant technologies had decreased and the precision of the technologies had increased, the Queensland Department of Agriculture and Fisheries (DAF), took the initiative of developing case studies on precision agriculture approaches in vegetables in a number of Australian states. These case studies were aimed at increasing the understanding of the applications by producers and local PA expertise businesses. The rationale was that such case studies would demonstrate the benefits of such technologies to vegetable producers as well as to potential businesses that might develop and supply such equipment.

DAF had previously carried out a successful precision agriculture project in Queensland that involved the whole precision agriculture supply chain. DAF therefore formed a team of vegetable producers, service providers, agronomists and other scientists to jointly fund and participate in the new project and develop the prospective case studies across Australia.

Project Details

Summary

Project Code: VG16009

Title: *Adoption of precision systems technology in vegetable production*

Research Organisation: Department of Agriculture and Fisheries, Queensland

Principal Investigators: Ian Layden, Leader, Horticultural Systems (Innovation), DAF; Julie O'Halloran, Senior Development Horticulturist, DAF

Period of Funding: October 2016 to October, 2019

Objective

The overall objective of the investment was to increase the rate of adoption of PA practices and processes to vegetable production systems across Australia, specifically targetting vegetable producers, vegetable agronomists and PA service providers. Specific objectives were:

- To increase the awareness and knowledge of what precision approaches can offer vegetable production systems.
- To increase precision technology skills in the vegetable supply chain and amongst service providers.
- To increase adoption of precision agriculture technologies by vegetable producers.
- To increase and improve networks and relationships to better position the industry to adopt new approaches.

Logical Framework

Table 2 provides a description of VG16009 in a logical framework.

Table 2: Logical Framework for Project VG16009

Activities	Governance, planning and management • Development of collaborator agreements. • Establishment of a project advisory panel. • Development of a Monitoring, Evaluation, Reporting and Improvement (MERI) Framework. Review of international PA • A literature review was undertaken on the available and emerging precision agriculture technologies relevant to the Australian vegetables industry. Establishment of demonstration and case study sites • Suitable case study and demonstration sites were identified based on collaborator and other networks, previous involvement in PA investment and cold calling. • Field sites were established for yield demonstrations and predictions for PA technologies across a range of vegetable case study sites in all six Australian states. • Monitoring and ground truthing at case study sites were carried out. • Data packages for each yield prediction site were developed. • Yield monitors were installed at three sites across Australia.

	• Various case studies for different PA applications were developed. Data science • High resolution satellite image data were sourced and analysed initially by project team members; however, this activity was later outsourced to commercial data service providers to facilitate relationships and build capacity available post-project. Communication and extension • A range of communication activities were undertaken throughout the project. • Capacity building training events were planned and carried out. • Particular attention was given to communicating evidence for change through the producer-led regional and crop specific case studies.

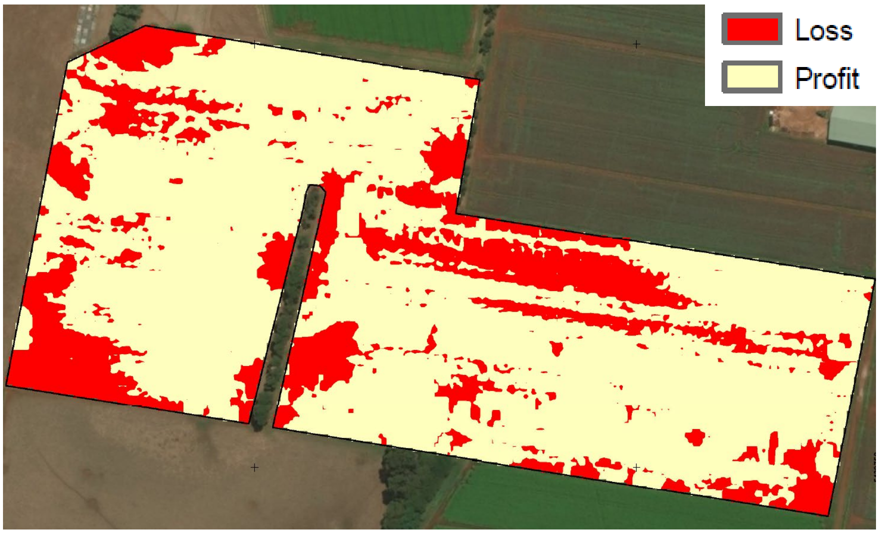
Outputs	• Advisory panel meetings were held throughout the project; these helped to maintain the purposeful objectives of the project and led the coordination and sequencing and interactions between project activities.
	• The MERI plan was developed and assisted with the successful delivery of outputs and outcomes.
	• The literature review was completed and published; the review addressed both the available and emerging PA technologies relevant to the Australian vegetables industry.
	• Outputs were delivered from the yield monitoring and case study sites including yield predictions, yield maps and various data packages.
	• For example, the installation of yield monitors to carrot harvesters assisted in understanding yield variations and the impact of yield monitoring using wireless data technology across the states was a major output.
	• The precision technologies addressed have assisted in identifying variation in, for example, soil pH, sodicity and other soil constraints, and nutrient and water drainage.
	• Communication outputs included project newsletters, factsheets, case studies, videos, podcasts, webinars, and magazine articles.
	• A set of recommendations was made by the project including:
	    o Given varying adoption profiles of PA adoption between regions, the associated regional enablers and barriers still require identification.
	    o The outcomes and networks developed during the project need to be further extended through Project VG18000 'National vegetable industry communications program'.
	    o A process of communication needs to be facilitated for the developing community of practice.
	    o Further research and development is required to effectively deploy yield predictions from remotely sensed imagery as a commercial service, as well as to guarantee the robustness of the approach across all growing regions.
	    o There is great potential to similarly evaluate the potential of remote sensing technologies for the improved monitoring of high

	risk pests and diseases, including those of high biosecurity importance. o Widespread PA adoption will require a more robust extension pathway; this was repeatedly highlighted throughout the project.
Outcomes	There is a real opportunity following VG16009 to build on the foundation and momentum initiated through this project. Some outcomes and value of PA can take longer timeframes to assess, such as yield and profitability benefits from variable rate soil amendments. As such, some sort of ongoing investment would allow for greater capture and quantification of these benefits over the longer term, as well as for the following project recommendations to be addressed (Julie O'Halloran, pers. comm., 2021): <u>Further identification of enablers and barriers</u> • DAF has assisted SEQ based growers to overcome adoption barriers of various technologies and to assist industry validate technologies such as smart insect traps <u>Further extension through Project VG18000</u> • Communication activities are ongoing through VG18000 and via DAF communication staff. DAF have had multiple discussions with VG18000 personnel and developed a communications plan that is delivering ongoing communication of VG16009 outputs. This includes social media communications around VG16009 video and factsheet/case study outputs. Most recently there is also a research update in development (i.e. Vegenotes story). It is expected that these communication activities will continue throughout 2021. Also, DAF has developed an ag-tech web site to house project resources. <u>Further R&D on yield prediction from remotely sensed imagery</u> • There is evidence that growers/agronomists engaged through the project are using drones to assess plant counts (forecasting yield) in hand harvested crops. <u>Further R&D re remotely sensed imagery for pest and disease</u> • There is evidence that vegetable agronomists are actively using drone-based data to identify crop constraints. <u>A more robust extension pathway</u> • DAF has developed the Gatton Smart Farm to assist growers to adopt technologies. <u>Other ongoing work includes</u>: • Grower co-operators involved in the project are continuing with follow on work. This includes continuing with the technologies implemented through the project as well as additional precision agriculture technologies. The extent to which this occurs will vary between co-operators and will most likely be linked to their relative experience with PA technologies. The relationships with PA service providers fostered through the project will also be critical to this ongoing work. Agronomists who undertook drone training through the project are continuing to develop these services for their clients or the businesses for which they work. The training provided networks with commercial drone operators and in many cases these agronomists have set up agreements with commercial drone operators to undertake the processing of the drone imagery. DAF has

continued to support growers interested in precision approaches and build on the work undertaken through VG16009. This includes various programs of work based at Gatton in the Lockyer Valley focused on precision tillage systems and SMART Farm sensor networks (Julie O'Halloran, pers. comm., 2021).

<u>Grower productivity and profitability outcomes</u>

- Productivity and profitability are longer term outcomes from precision agriculture approaches and there was insufficient time to see such outcomes within the timeframe of the project. Crop sensing and yield mapping technologies provided information for growers to quantify underperforming areas (e.g. x% of this field is underperforming by y tonnes/ha). This information could be used to quantify financial costs of these underperforming areas relative to crop inputs and determine whether any management intervention is likely to be cost effective. In the carrot examples below, yield mapping data was used to calculate gross margin and profit loss maps so that growers could see which areas of the field were costing money rather than producing an income.
- Example: Gross margin percentage (%) map generated from carrot yield mapping data (Julie O'Halloran, pers. comm., 2021).



- The profit loss map shows the ratio of gross margin: variable costs (where ratio less than 1:1 is loss (highlighted red) and where the ratio is greater than 1:1 is designated profit).
- Soil mapping technologies were used to inform changes in how crop inputs were targeted in the case studies. Where possible this did make reference to how these altered crop inputs compared with standard practices and again this varied. For example, in some cases inputs were more but more targeted or the same but more targeted.
- Subsequent work could follow up with case study growers and assess whether there had been any long-term gains from the precision approaches implemented. However, without further support it is

	possible that growers in the short term will not monitor sufficiently to have quantitative evidence of productivity gains. • A key difficulty with initial steps in PA approaches is putting a dollar figure on the benefit of having a greater level of detailed information about a crop or field to make management decisions or understanding the cause of an underperforming area. Given the timeframe of the project, this is as far as most case studies progressed. Also, a key cost in PA implementation is the grower's time, not so much the cost of the technology although obviously that is a consideration as well (Julie O'Halloran, pers. comm., 2021). In summary, the key grower outcomes are summarised as: • Changes in awareness and knowledge by growers and other industry personnel concerning potential PA technologies and the opportunities that exist for their application in vegetable growing. • Increased awareness of growers and others regarding the likely returns to investment in various PA technologies. • Increased propensity for some vegetable growers to invest in adoption of some PA technologies and associated tools.
Impacts	• Acceleration of the future adoption/use of PA technologies by Australian vegetable growers resulting in increased productivity and profitability of vegetable production, particularly in the longer term. • Potentially, more targeted use of inputs (e.g. fertilisers) resulting in increased productivity and less export of nutrients to external environments. • Potentially, more targeted use of pest control chemicals resulting in slower development of resistance and in reduced chemical export to external environments. • Increased capacity and skills by vegetable growers and supply contractors throughout Australia in the use and delivery of PA technologies. • Potentially, future improved regional community wellbeing from spillover benefits from the increased productivity and profitability of vegetable growers.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project VG16009 by Hort Innovation and a range of other investors. The other investors included Serve-Ag (Tasmania), University of Tasmania (UTAS), University of New England (UNE), Harvest Moon, Vegetables Western Australia, Primary Industries and Regions South Australia (PIRSA), and the Society of Precision Agriculture Australia. Early in the project, Serve-Ag notified DAF that they were no longer in a position to provide the intended support and their role and funding was absorbed by UTAS. Serve-Ag remained in the project but as a provider of agronomy services to producers.

Table 3: Annual Investment in Project VG16009 (nominal $)

Year ended 30 June	Hort Innovation ($)	Others[(a)] ($)	Total ($)
2017	1,351,250	979,507	2,330,757
2018	446,750	323,845	770,595
2019	400,500	290,318	690,818
2020	549,720	398,486	948,206
Totals	2,748,220	1,992,156	4,740,376

Source: VG16009 Project Research Agreement supplied by Hort Innovation 2021

(a) Other investment by year was estimated from the total investment by others according to the same annual proportion of total investment made by Hort Innovation.

Program Management Costs

For the Hort Innovation investment the cost of managing and administrating the Hort Innovation funding was added to the Hort Innovation contribution for the project via a management cost multiplier (1.162). This multiplier was estimated based on the share of 'payments to suppliers and employees' in total Hort Innovation expenditure (3-year average) reported in the Hort Innovation's Statement of Cash Flows (Hort Innovation, various years). This multiplier was then applied to the nominal investment by Hort Innovation shown in Table 3.

For the investment by other funders it was assumed that the management and administration costs were already included in the nominal values reported in Table 3.

Real Investment and Extension Costs

For the purposes of the investment analysis, investment costs of all parties were expressed in 2019/20 dollar terms using the Gross Domestic Product deflator index (ABS, 2021). No additional costs associated with project extension were incorporated as the project included a high level of industry participation and a number of communication and awareness activities throughout the duration of the project. These activities informed the relevant vegetable growers and other industry stakeholders (e.g. consultants, researchers and potential investors) as part of the project, as well as government stakeholders.

Impacts

Table 4 provides a summary of the principal types of impacts delivered by the project. Impacts have been categorised into economic, environmental and social impacts.

Table 4: Triple Bottom Line Categories of Principal Impacts from Project VG16009

Economic	• Increase in future use of precisions agriculture (PA) technologies by levy paying Australian vegetable growers resulting in increased productivity and profitability of vegetable production.
Environmental	• More targeted use of inputs (e.g. fertilisers) resulting in export of nutrient to external environments. • More targeted use of and pest control chemicals resulting in slower development of resistance and in reduced chemical export to external environments.
Social	• Increased capacity and skills by vegetable growers and supply contractors throughout Australia in the use of PA technologies. • Potentially, future improved regional community wellbeing from spillover benefits from the increased productivity and profitability of vegetable growers.

Public versus Private Impacts

Impacts identified in this evaluation are both private and public in nature. Private benefits are likely to be realised by Australian vegetable growers and those businesses supporting precision agriculture associated with vegetable growing. Public benefits may include the increased capacity built in public sector agencies associated with PA use in vegetable production. Also, there may be some positive environmental impacts derived from the increased use of PA technologies in vegetable production.

Distribution of Private Impacts

The impacts on the Australian horticultural industries that may benefit from the project will be shared with businesses involved in supplying PA services , as well as various other input and output supply chains including other input suppliers, growers, vegetable supply chain businesses post farm gate and consumers. The share of impact realised by each link in the supply chain will depend on both short- and long-term supply and demand elasticities in the various vegetable supply chains.

Impacts on Other Australian Industries

Impacts from the project investment will be largely specific to levy-paying vegetable growers; however, there may be some spillover impacts to some vegetable growers that are not covered by the national vegetable levy.

Impacts Overseas

No significant or direct overseas impacts were identified.

Match with National Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 5. The project findings and related impacts will contribute to Rural RD&E Priority 1, with some potential contribution to Priority 4, and to Science and Research Priority 1.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	**Science and Research Priorities (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 6. Resources 7. Advanced Manufacturing 8. Environmental Change 9. Health

Sources: DAWR (2015); Australian Government, Office of the Chief Scientist (2015)

Alignment with the Strategic Investment Plans for the Vegetable Industry 2017-2021

The strategic outcomes and strategies of the Vegetable industry are outlined in the Vegetable Industry's SIP 2017-2021[1] (Hort Innovation, 2017). Project VG16009 addressed three SIP Outcomes in the Plan:

- Outcome 3: Increased farm productivity and decreased production costs through better utilisation of resources, adaptation to climate, reduced impact of pests and diseases and better utilisation of advanced technologies on the farm.
(Strategy 3.2, 3.7, and 3.8)
- Outcome 4: Increased supply chain integration and development through improved supply chain management, development of collaborative models and partnerships.
(Strategy 4.3)
- Outcome 5: Improved capability of levy payers to adopt improved practices and new innovation through improved communication and extension programs, grower innovation support, professional development and workforce building programs, and through improved farm management and information systems.
(Strategy 5.2, 5.3, and 5.4)

[1] For further information, see: https://www.horticulture.com.au/hort-innovation/funding-consultation-and-investing/investment-documents/strategic-investment-plans/

Valuation of Impacts

Impact Valued

Only one impact was valued; the impact was the likely future productivity and profitability gain by vegetable producers due to the investment in VG16009.

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

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. Specifically, within the scope of the current Hort Innovation impact assessment program, environmental and social impacts were difficult to value due to lack of evidence/data on which to base credible assumptions, difficulty in quantifying the causal relationship and the pathway between the investment, and the impact and the complexity of assigning magnitudes and monetary values to such impacts.

The environmental impact identified but not valued was:

- Potentially, some contribution to improved environmental outcomes through increased adoption of changed management practices associated with increased spatial knowledge and the associated use of nutrients and chemicals with potentially lowered negative impacts of export off farm of excess nutrients and chemicals.

The social impacts identified but not valued were:

- Increased capacity and skills by vegetable growers and supply contractors throughout Australia in the use of PA technologies.
- Potentially, future improved regional community wellbeing from spillover benefits from the increased productivity and profitability of vegetable growers.

The contribution to increased capacity and skills of growers and of spatial technology input supply chains were captured, at least in part, by the impact valued. The community spillover benefits from reduced losses to growers were not valued largely due to a lack of data and its complexity to support credible assumptions (e.g. the number of industries involved and their multiple geographic locations).

Valuation of Impact: Future Productivity and Profitability Gain

The impact valued was the productivity and profitability gain by vegetable producers due to the investment in VG16009. A summary of the key assumptions made for valuation of the impact is shown in Table 6.

Attribution

The productivity and profitability gains likely to be driven by the project investment will not be delivered without additional costs to vegetable growers and others in the associated supply chains. Such costs, for example, would include any additional capital and operating costs. Hence, an attribution factor of 75% was applied to the benefits estimated to accommodate such additional costs.

Counterfactual

It was assumed that, in the absence of the investment in VG160009, the benefits identified and valued would still have occurred but at a later time (10 years).

.

Table 6: Summary of Assumptions for Impact of VG16009

Variable	Assumption	Source/Comment
Base industry information		
Average annual value of Australian vegetable production	4,640.8 $m	3 year average 2018-2020 Hort Innovation (2020)
Existing profit as % gross value	11.76%	ABARES (2020)
Impact of Project VG16009		
Maximum proportion of all vegetables produced with some form of PA in 10 years	5% (a)	Analyst assumptions that include both levied and non-levied production, as it is assumed there will be spillovers to non-levied vegetable industries.
Profitability increase due to PA	20%	
First year of project impact resulting in profitability gain	2022	
Year of maximum impact	2026	
Years to maximum profitability gain	5 years (2022 to 2026) with linear progression of profitability gain over this period	
Estimate of gross value affected at maximum impact	232.04 $m per annum	4640.8 x 5%
Maximum profit gain for the 5%	5.46 $m per annum	232.04 x 11.76% x 20%
Counterfactual		
Benefits valued would still have occurred but at a later time (10 years later).		Analyst assumption
Attribution		
Attribution of benefits to Project VG16009	50%	Allows for other extension and cost items that potentially will be incurred in capturing the impacts valued
Risk factors		
Probability of outputs of VG16009	100%	Project outputs already delivered
Probability of outcomes (usage in future of PA technologies for vegetables)	75%	Analyst assumptions
Probability of impact given a successful outcome	75%	

(a) Australian vegetable production that is not levied is estimated at 52% of total vegetable production; this is based on at least 1,95 m tonnes per annum of production of non-levied vegetables (e.g. including potatoes, sweet potatoes, pumpkins, onions and tomatoes), from a total production of 3.7m tonnes per annum for all vegetables.

Results

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 project investment period plus 30 years from the last year of investment (2019/20) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Table 7 shows the investment criteria estimated for different periods of benefit for the total investment. Table 8 shows the investment criteria estimated for different periods for the Hort Innovation only. The present value of benefits (PVB) for Hort Innovation was estimated by multiplying the total PVB by the proportion of Hort Innovation investment in project VG16009 61.6%).

Table 7: Investment Criteria for Total Investment in Project VG16009

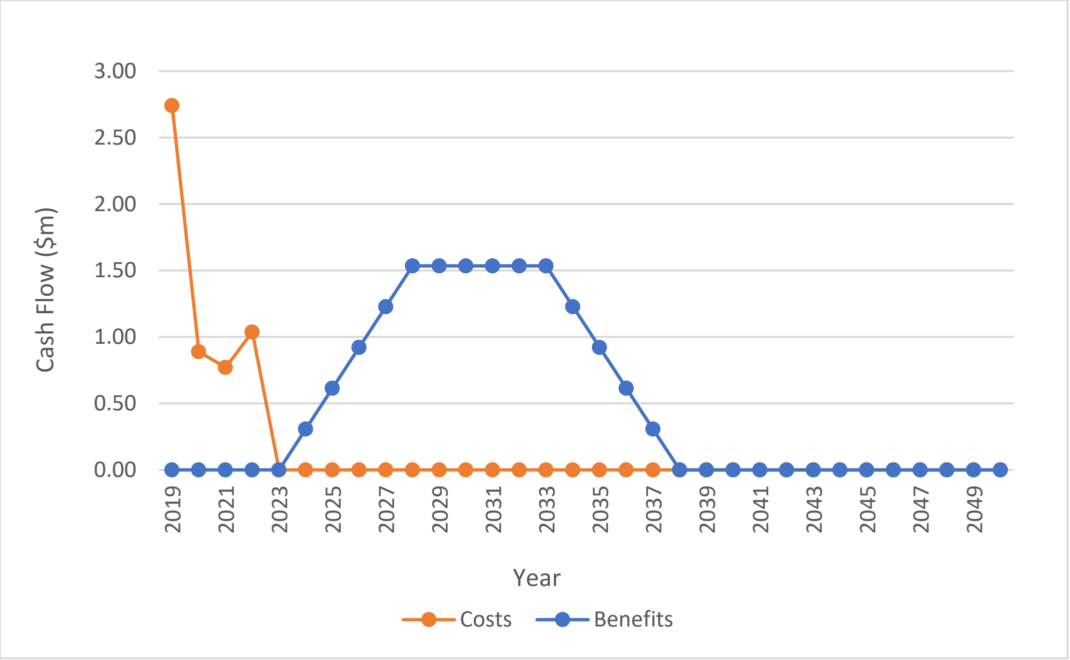
Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits $m)	0.00	2.53	7.74	10.26	10.26	10.26	10.26
Present Value of Costs ($m)	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Net Present Value ($m)	-6.00	-3.47	1.74	4.26	4.26	4.26	4.26
Benefit-Cost Ratio	0.00	0.42	1.29	1.71	1.71	1.71	1.71
Internal Rate of Return (%)	negative	negative	8.2	10.9	10.9	10.9	10.9
MIRR (%)	negative	negative	7.7	8.8	7.9	7.3	6.9

Table 8: Investment Criteria for Hort Innovation Investment in Project VG16009

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits $m)	0.00	1.56	4.76	6.32	6.32	6.32	6.32
Present Value of Costs ($m)	3.69	3.69	3.69	3.69	3.69	3.69	3.69
Net Present Value ($m)	-3.69	-2.14	1.07	2.63	2.63	2.63	2.63
Benefit-Cost Ratio	0.00	0.42	1.29	1.71	1.71	1.71	1.71
Internal Rate of Return (%)	negative	negative	8.2	10.9	10.9	10.9	10.9
MIRR **(**%)	negative	negative	6.5	8.2	7.4	6.9	6.6

The annual undiscounted benefit and cost cash flows for the total investment for the duration of VG16009 investment plus 30 years from the last year of investment are shown in Figure 1.

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



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 9 presents the results. The results show a moderate sensitivity to the discount rate. This is largely due to the length of the period between the end of the investment and any significant adoption of PA technologies by vegetable growers.

Table 9: Sensitivity to Discount Rate

Investment Criteria	**Discount rate**		
	0%	**5%**	**10%**
Present Value of Benefits ($m)	15.35	10.26	7.15
Present Value of Costs ($m)	5.44	6.00	6.61
Net Present Value ($m)	9.91	4.26	0.54
Benefit-cost ratio	2.82	1.71	1.08

A sensitivity analysis was then undertaken for the assumption regarding the maximum proportion of vegetable produced using some form of PA in 10 years ahead, currently assumed at 5%. The results are presented in Table 10 and show a significant sensitivity to the assumed proportion. The breakeven in the assumed proportion has to reach 2.9% for the investment in project VG16009 to break even, given all other assumptions remaining the same.

Table 10: Sensitivity to Maximum Proportion of Vegetable Production in 10 Years

Investment Criteria	**Change in Assumed Area Affected Without and With the Project**		
	2.5%	**5%**	**10%**
Present Value of Benefits ($m)	5.13	10.26	20.53
Present Value of Costs ($m)	6.00	6.00	6.00
Net Present Value ($m)	-0.87	4.26	14.53
Benefit-cost ratio	0.86	1.71	3.42

Confidence Rating

The results produced are highly dependent on the assumptions made, many 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 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
High-Medium	Medium-Low

Coverage of benefits was assessed as High–Medium as the impact valued is likely to be the most important. However, confidence in assumptions was rated as Medium-Low. The assumptions were made with a high degree of uncertainty regarding the rate of future adoption of PA in the vegetable industry, the timing of such adoption, the levels of the various risk factors assumed, the attribution of the impact assumed specifically to project VG16009, and the assumption addressing the counterfactual (what would have occurred without the investment in VG16009.

Conclusion

The investment in VG16009 has contributed to a higher level of awareness and knowledge about PA techniques that may be used in future vegetable production in Australia. As a result, VG16009 is likely to have contributed to future development of use of precision farming applications in the Australian vegetable industry with associated productivity and environmental benefits.

Total funding from all sources for the project was $6.00 million (present value terms). The investment was estimated to produced total expected benefits of $10.26 million (present value terms). This gave a net present value of $4.26 million, an estimated benefit-cost ratio of 1.7 to 1, an internal rate of return of 10.9% and a modified internal rate of return of 6.9%. The estimated benefits were driven by the impact of the likely gain in profitability of the future use of PA in the Australian vegetable industry.

Several environmental and social impacts were also identified but not valued as part of the current assessment. Given the impacts not valued, combined with conservative assumptions made for the principal economic impacts valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the VG16009 investment.

Glossary of Economic Terms

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

References

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (2020) Farm Survey Data for Australian Vegetable Industry. Retrieved from: https://www.agriculture.gov.au/abares/research-topics/surveys/vegetables#detailed-physical-characteristics

Australian Bureau of Statistics. (2021, February 15). 5206.0 - Australian National Accounts: National Income, Expenditure and Product, Dec 2019. Retrieved June 2020, from Australian Bureau of Statistics: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5206.0Dec%202019?OpenDocument

Australian Government (2015). Science and Research Priorities. Canberra: Commonwealth of Australia.

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

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

Hort Innovation (2017) Vegetable Strategic Investment Plan 2017-2021. Retrieved from: https://www.horticulture.com.au/hort-innovation/funding-consultation-and-investing/investment-documents/strategic-investment-plans/

Hort Innovation (2020) Australian Horticultural Statistics Handbook Retrieved from https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/australian-horticulture-statistics-handbook/

Acknowledgements

AgEconPlus and Agtrans Research would like to thank all the project and program personnel associated with Horticulture Innovation Australia Limited that were involved in the evaluation process. Their cooperation and feedback throughout the evaluation process contributed significantly to this report.

Specific acknowledgments:

Adam Briggs, Head of Data & Insights, Horticulture Innovation Australia

Ian Layden, Director, Vegetables, Systems and Supply Chains, Department of Agriculture and Fisheries

Julie O'Halloran, Senior Development Horticulturist, Department of Agriculture and Fisheries

Abbreviations

ABARES	Australian Bureau of Agricultural Resource Economics and Sciences
ABS	Australian Bureau of Statistics
DAF	Department Agriculture and Fisheries, Queensland
DAWR	Department of Agriculture and Water Resources
Hort Innovation	Horticulture Innovation Australia Ltd
$m	$ million
MIRR	Modified Internal Rate of Return
PA	Precision Agriculture
PVB	Present Value of Benefits
R&D	Research and Development
RD&E	Research, Development and Extension
SIP	Strategic Investment Plan