Final Report

Economic impact assessment for Hort Frontiers: An evaluation of *Securing pollination for productive agriculture* (PH16004)

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Delivery partner:

AgEconPlus

Project code:

HA20000

Project:

Economic impact assessment for Hort Frontiers (HA20000)

Disclaimer:

Funding statement:

This project has been funded by Hort Innovation, using across industry research and development levies 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

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Contents

List of Tables

List of Figures

Public summary

Hort Frontiers invests funds from a wide range of co-investors including businesses, research agencies, government departments, education institutions, the Australian Government and horticulture levies. Economic impact assessment of these investments is required to meet Hort Innovation obligations under its Organisational Evaluation Framework, its Statutory Funding Agreement, and to demonstrate a return to a diverse set of co-investors and other stakeholders.

This economic impact assessment of the Hort Frontiers program addresses these requirements through the completion of a series of project-specific, ex-post, independent impact assessments of the program. The economic impact assessment was completed using guidelines prepared by the Council of Rural Research and Development Corporations (CRRDC 2018).

The project assessed in this impact assessment *was PH16004: Securing Pollination for Productive Agriculture: Guidelines for Effective Pollinator Management and Stakeholder Adoption*. The Hort Frontiers project has contributed to a larger Australian Government, Rural Research and Development for Profit, project and delivered progress toward improved crop pollination, produce quality, and yield. The project delivered recommendations for nine crops (almond, apple, blueberry, lucerne seed, mango, melon, pear, and raspberry). Project costs were large and upfront while benefits are likely to be concentrated in the future, rather than the near-term. Consequently, return on investment was modest even with analysis over thirty years from the last year of project investment.

Technical summary

This report presents the results of an impact assessment of a Hort Frontiers Pollination Fund project *PH16004: Securing Pollination for Productive Agriculture: Guidelines for Effective Pollinator Management and Stakeholder Adoption*. The project was funded by Hort Innovation over the period May 2017 to March 2021.

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 2021/22-dollar terms and were discounted to the year 2022/23 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).

The Hort Frontiers project has contributed to a larger Australian Government Rural Research and Development for Profit project and delivered progress toward improved crop pollination, produce quality, and yield. The project delivered recommendations for nine crops (almond, apple, blueberry, lucerne seed, mango, melon, pear, and raspberry). Project costs were large and upfront while benefits are likely to be concentrated in the future, rather than the near-term. Consequently, return on investment was modest even with analysis over thirty years from the last year of investment.

Total funding from all sources for the project was $19.83 million (present value terms). The investment produced estimated total expected benefits of $22.44 million (present value terms). This gave a net present value of $2.61 million, an estimated benefit-cost ratio of 1.13 to 1, an internal rate of return of 5.4% and a modified internal rate of return of 5.3%.

As one economic, one environmental and two social impacts were not valued, the investment criteria estimated by the evaluation may be underestimates of the actual performance of the investment.

Keywords

Impact assessment, cost-benefit analysis, pollination, honey bees, native pollinators, native vegetation, Varroa mite, crop yield and quality, almond, apple, blueberry, canola, lucerne seed, mango, melon, pear, and raspberry.

Introduction

The Hort Frontiers program facilitates collaborative cross-industry investments that are focused on high-risk, transformative research, development, and extension (RD&E) with the potential for significant impact. Investments are longer-term, complex, and focus on traditionally underinvested themes.

Hort Frontiers invests funds from a wide range of co-investors including businesses, research agencies, government departments, education institutions, the Australian Government and horticulture levies. Economic impact assessment of these investments is required to meet Hort Innovation obligations under its Organisational Evaluation Framework, its Statutory Funding Agreement, and to demonstrate a return to a diverse set of co-investors and other stakeholders.

This economic impact assessment of the Hort Frontiers program addresses these requirements through the completion of a series of project-specific, ex-post, independent impact assessments of the program. A total of eight (8) RD&E investments (projects) were selected through a stratified, random sampling process. The projects, and the total life-of-project (LOP) value of their Hort Innovation managed investment in nominal terms are described in Table 1.

Table 1: Hort Frontiers Project Sample for Impact Assessment

Hort Frontiers Fund	Project Code	Project Title	Total LOP Investment[(a)] (nominal $)
Advanced Production Systems	AS19005	Australian Protected Cropping RD&E Strategy 2030	140,322
Fruit Fly	HG14033	SITplus: Raising Qfly Sterile Insect Technique to World Standard	20,502,806
Green Cities	GC15002	Which plant where when and why database	10,573,638
Health, Nutrition & Food Safety	HN15000	Innovative Cold Plasma for Horticultural Industries	5,080,321
International Markets	AM15007	Market Development Program - Almonds	925,499
International Markets	AM17001	Developing a national systems approach for meeting bio-security requirements to access key Asian markets	4,830,614
Leadership	LP15001	Global Masterclass Horticulture	3,235,805
Pollination	PH16004	Securing pollination for productive agriculture: guidelines for effective pollinator management and stakeholder adoption	2,182,967

(a) Hort Innovation managed investment

The project population for each fund from which the random sample was selected included completed projects where a final deliverable had been submitted and accepted in the three-year period from 1 July 2019 to 30 June 2022.

The projects in the random sample were selected such that:

(1) The total LOP sample value (in nominal dollar terms) represented at least 10% of the total Hort Innovation managed investment in the overall Hort Frontiers project population, and
(2) The total Hort Innovation managed investment in each project was greater than, or equal to, $100,000 (to exclude 'trivial' projects).

Further, the random sample was stratified first by Hort Frontiers Fund, to ensure all relevant Funds were represented, and then by LOP value range.

The final stratified random sample shown in Table 1 included the required eight (8) projects. At least one project from each Hort Frontiers Fund was selected and at least one project from each LOP range (as defined by Hort Innovation). The final random sample had a total nominal LOP value of $47.47 million (Hort Managed investment) equivalent to approximately 51.6% of the overall total nominal LOP value in the population. Also, the final random sample included one project completed in 2019/20, two completed in 2020/21, and five completed in 2021/22 (all relevant years represented).

Project PH16004: *Securing pollination for productive agriculture: guidelines for effective pollinator management and stakeholder adoption* was one of the investments randomly selected and is analysed in this report.

Methodology

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

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

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

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

Where impact valuation was exercised, the impact assessment used cost-benefit analysis (CBA) as a principal tool. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for the individual investment evaluated are likely to represent an underestimate of the true performance of the investment.

Background and Rationale

The Hort Frontiers Pollination Fund Project, “PH16004: Securing pollination for a more productive agriculture, guidelines for effective pollinator management and stakeholder adoption” was a priority for investment given Australia’s reliance on insect pollination of its food supply and threats to the European honey bee (*Apis mellifera*). In Australia, about one third of the food we eat comes from insect-pollinated crops and more again from pastures that are insect pollinated. In total, more than 50 different agricultural and horticultural commodities rely on insect pollination.

Most of Australia’s fast-expanding, high-value horticultural crops require insect pollination either to produce a profitable crop, or at the point of seed supply. Pollination is also important to several broadacre seed crops, such as canola and lucerne. Pollination not only supports the quantity of production, but for many crops it ensures a higher quality, more valuable product (e.g., better shaped fruit with improved storage traits).

The supply of pollinating honey bees is under threat. The eventual establishment in Australia of the honey bees’ most significant pest, and conduit for honey bee viruses, Varroa destructor (Varroa) is considered likely. Furthermore, the supply of honey bees for pollination is adversely impacted by land management policies that reduce the quantity and quality of floral resources available for honey production and colony strengthening prior to pollination. Land management policies impacting honey bees include unfavourable public land tenure changes, excessive timber harvesting on remaining land, and failure to control wildfire.

Native insect pollinators already provide an estimated $2.5 billion in free service to Australian agriculture, but it is widely understood that this benefit can be increased by good natural resource management. Strategies are needed to exploit this advantage for Australian growers. Strategies are needed to add value to existing pollination services and reduce the risks associated with reliance on the honey bee.

While the honey bee will remain the most versatile and ubiquitous managed pollinator, there are opportunities to enhance productivity and decrease risk by supporting a diverse, abundant, and healthy supply of crop pollinators.

Rationale

Prior to the project, investment was required to address threats to honey bees by improving the capacity of agricultural land to support them post-Varroa establishment. The project would also boost the population of native pollinators, such as native bees, butterflies, and flies, which are not susceptible to Varroa. Revegetation on or around farms that support pollinators has been shown to enhance crop pollination and this is an established strategy in both Europe and the United States.

The research was to determine which pollinators are supporting current agricultural production (i.e., wild species, hived honey bees, and unmanaged honey bees) and was to allow an assessment of how this service will change with the establishment of Varroa in Australia. The project was to identify practices that ensure provision of an ongoing pollination service by:

1) Providing resources in and around crops for non-honey bee pollinators.
2) Providing food resources for commercially managed honey bees, to support the best possible population strength even when Varroa has established.

The project was the first in Australia to determine the ways in which growers can harness the pollination capacity of native and exotic pollinators in an integrated way. The underlying principle was that farmers and other land managers can support increased pollinator populations (wild and managed) by small, targeted investments in growing the resource base. The project aimed to increase grower profits and minimise the risk of a pollinator shortfall. It was also to provide lasting environmental benefits associated with actively engaging growers in revegetation and the management of remnant vegetation on their properties.

The project selected case study crops that provide a general model for how production benefits can be maximised, so that practices can then be rolled out for other Australian pollinator dependent crops. Case study crops included almonds in SA, apple in SA and NSW, blueberry in NSW, canola in SA, lucerne seed in SA, mango in QLD, melon in QLD, pear in SA and NSW, and raspberry in NSW. The cropping system management studied is, however, specific to each region and crop, particularly with regards to opportunities for improved pollinator management.

The Hort Frontiers Pollination Fund Project, “PH16004: Securing pollination for productive agriculture, guidelines for effective pollinator management and stakeholder adoption” was part of a larger Australian Government Rural R&D for Profit (RND4P) investment. Investment funds from the Hort Frontiers Pollination Fund were used to augment funding from a project of the same name managed by AgriFutures Australia. The RND4P project targeted four key areas:

1) For targeted crops, assess density and efficiency of pollinators, and identify the natural resources that support their presence in the crop.
2) Use knowledge of resource requirements to design, establish and test pollinator habitat.
3) Identify the value of the restoration of pollinator habitat and the barriers to adoption by organising conservation auctions, for planting pollinator supporting habitat around lucerne crops.
4) Develop tools for producers to improve commercial outcomes by improved pollinator management.

Project Details

Summary

Project Code: PH16004.

Title: *Securing Pollination for a More Productive Agriculture, Guidelines for Effective Pollinator Management and Stakeholder Adoption*

Research Organisations: AgriFutures Australia, Australian National University (ANU, Saul Cunningham), University of Adelaide (Andy Lowe, Katja Hogendoorn), University of New England (UNE, Romina Rader), University of Sydney (USYD, Ben Oldroyd), Hort Innovation (Ashley Zamek).

Project Leader: Jill Whitehouse, AgriFutures Australia.

Period of Funding: May 2017 to March 2021 (final report date).

Objectives

The objectives of PH16004 were to:

- Complement the R&D activities stipulated in the current RND4P project of the same name led by AgriFutures Australia in partnership with ANU, University of Adelaide, UNE, USYD and 14 other partners including industry associations.
- Assess the contribution of all pollinators to 9 crops (almond, apple, blueberry, canola, lucerne seed, mango, melon, pear, and raspberry) and re-establish native vegetation to support pollinator food and nesting resources.
- Deploy new technologies to communicate the new practices and knowledge to growers.
- Improve the capacity of agricultural land to support hived honey bees prior to the arrival of Varroa.
- Optimise crop yield and strengthen pollination security.
- Industries that also acted as partners in the project included apple and pear, lucerne, almonds, melons, mangoes, beekeeping, raspberries, and blackberries. In addition, a number of State Government Departments and natural resource management organisations provided support in both project activities and funding.

Logical Framework

Table 2 provides a detailed description of project PH16004 in a logical framework.

Table 2: Logical Framework for Project PH16004

Activities	• RD&E activities as described in the final PH16004 project report (Whitehouse 2021): • Field research to identify crop visiting insects, their abundance, and pollination efficiency. Nine crops were assessed. • Assessment of the density of unmanaged honey bee colonies – feral honey bee hives assessed at various locations in south-eastern Australia and the method employed validated in Urrbrae SA. • Assessment of the importance of natural habitat for crop pollinators – apple in VIC and TAS, apple and berries QLD and NSW, and apple and lucerne in SA. • Assessments also made of the link between the presence of woody habitat for pollinators and produce quality (apple and lucerne seed), and the effect of nesting resource provision (for stem nesting bees) and berry pollination. • Design of revegetation plots for pollinators using literature, field observations, insect visitation data, pollen analysis, and consultation with beekeepers. • Local food and nesting substrata plants identified for native bees visiting apple, berries and lucerne. • Creation of a DNA sequence repository in SA to maintain a record of crop pollinating bees, crop and native vegetation pollen carried by bees. • Investigation of the importance of plant diversity on the number of native bee species present and their abundance.

	• Design of revegetation strategies with growers, and revegetation specialists at 5 on farm demonstration sites in SA. • Documentation of the costs of demonstration plantings and modelled of longer-term benefits using PIRSA software. • Delivery of a reverse conservation auction to reveal the general costs of diverse plantings and the perceived value of planting for pollinators. A reverse auction is a tender process whereby bidders are invited to estimate the cost of delivering a service, such as revegetation, to a certain standard. • The minimum cost of high-quality revegetation was established at $25,000/ha (Whitehouse 2021 page 58).
Outputs	• An understanding of the identity, density, and efficacy of insect visitors to nine pollination dependent crops. The project identified a wide range of insects that visit crop flowers and found that the most efficient and abundant pollinators differed by crop, by region, and over time. • Pollinator populations are dependent on the presence of flowering plants in the landscape. The proximity and composition of native vegetation influences the abundance and diversity of crop pollinating species. • An understanding of the nature and extent of the main threats to pollination security – a decrease in floral support for pollinators in the landscape and an increase in the reliance on a single vulnerable pollinator (honey bees). • Unmanaged (feral) honey bees play a major role in crop pollination, particularly in dryland lucerne and apple (the two crops studied). However, in less forested areas their densities are not high enough to provide all the pollination required. Unmanaged honey bees are dependent on nesting hollows (often found in old eucalypts) and drinking water within 2-5 km of the crop. • Currently, and prior to the establishment of Varroa, unmanaged honey bee hives account for about half of the free pollination services in Australian agriculture. • Crop and landscape management strategies are required to secure pollination services into the future. Different pollinating species require floral resources to support their activities at different times of the year. Floral support should be available year-round and within a maximum of 200 metres of the crop. A wide variety of pollen and nectar sources are needed. • The project recommended that a wide range of local, easy to grow native species be planted. Planting design can focus on understory species, hedgerows, or whole area planting. These plantings will also provide a range of other benefits for farm productivity (e.g., livestock shelter belts and erosion prevention). • Nesting substrata for volunteer pollinators should also be provided. Appropriate substrata include bundles of sticks with pithy stems for reed bees, compacted well drained soil for ground nesting furrow and nomia bees, and leaving old paddock trees in place to provide nesting hollows for feral honey bees and stingless bees. • Pollination efficiency gains (e.g., a 5% to 15% improvement) that may be associated with suitably improved native vegetation in proximity to crop will vary with distance. For example, at the edge of the native vegetation the yield is generally 5% to10% higher than deeper in the field and this declines to 0% over a distance of 200 metres. • No information was reported on the translation of pollination efficiency gains into crop yield gains (e.g., pollination efficiency gain of 10% provides a yield/quality gain of 5%). • The project included revegetation of approximately 25 ha of land (5 sites each of 5 ha) in SA near commercial crop. • The project delivered a final Hort Innovation report and communication material including a “glossy” project summary, a video explainer on how to enhance pollination security, factsheets on which pollinators are visiting which crops, a pollinator identification app, a video on securing pollination through revegetation, strategies to protect hived honey bees when they move from crop to crop, best practice Varroa management, a review of the literature on pollinator habitat (published), a pollinator

	food availability calculator with associated maps, and a video on feral honey bees and the importance of hollows in old eucalypt trees. • Outputs were communicated through websites (e.g., Pollin8), industry newsletter articles, oral presentations to grower and beekeeper industry groups, conferences, field days, workshops, via the media (including television, radio, newspapers, and social media), scientific publications, and even a pollinator song.
Outcomes	• The potential for improved landowner management of native vegetation areas, new native vegetation areas (revegetation), and pollinator habitats. • Progress toward improved crop pollination, produce quality, and yield. Key industries that will be impacted include almond, apple, blueberry, canola, lucerne seed, macadamia, mango, melon, and pear. • Potential contribution to strategies that will reduce the impact of Varroa if it establishes in Australia via increased capacity of revegetated land to support managed honey bees, with stronger colonies better able to manage mite infestation. Additional native pollinators may also be available to help replace unmanaged (feral) honey bees lost to Varroa.
Potential Impacts	• Economic – progress toward increased enterprise returns with improved pollination, average crop yield and quality for some crops in some locations. • Economic – potential for reduced crop yield loss with Varroa mite (or a similar honey bee pest e.g., tropilaelaps) establishing in Australia. • Economic – spill-over benefits including shade/shelter for livestock, and erosion control following the planting of native vegetation to encourage pollinators. • Environmental – additional biodiversity within the farm environment e.g., additional native pollinators and the presence of native birds and small mammals which feed on pollinators and additional populations of other insects. • Environmental – increased carbon sequestration with an increase in revegetated land and native vegetation managed for pollination. • Capacity - additional skills in understanding and managing pollinators. Skills developed by researchers (including postgraduate, PhD, and post-doctoral training) and growers (planting and vegetation management for pollination). • Capacity - a repository of DNA data in SA on crop pollinating bees, and pollen types. Data available as an aid to future research. • Social - contribution to improved regional community wellbeing from spill-over income and employment benefits as a result of more productive and profitable agricultural industries.

Project Investment

Nominal Investment

Table 3 shows the annual investment made in Project PH16004.

Table 3: Annual Investment in Project PH16004 (nominal $)

Year (ended 30 June)	HORT FRONTIERS ($)	OTHERS ($)	TOTAL ($)
2016	0	1,295,972	1,295,972
2017	587,785	1,760,183	2,347,968
2018	587,784	3,056,152	3,643,936
2019	618,900	3,217,938	3,836,838
2020	289,276	1,504,077	1,793,353
2021	142,244	739,593	881,837
Total	2,225,989	11,573,915	13,799,904

Source: Hort Innovation fully executed letter of variation, 6 November 2019 and AgriFutures Australia (https://www.agrifutures.com.au/partnerships/rural-rd-for-profit-program/securing-pollination/#:~:text=AgriFutures%20Australia%20has%20been%20awarded,pollinator%20management%20and%20stakeholder%20adoption.)

In addition to Hort Frontiers managed funds, other investors included the Australian Government Department of Agriculture, Fisheries, and Forestry, AgriFutures Australia, and four universities (Australian National University, University of Adelaide, University of New England, and the University of Sydney). Also, cash and in-kind support for the project from a range of primary industries was provided, including significant support from Hort Innovation. Industries who also acted as partners in the project included apple and pear, lucerne, almonds, melons, beekeeping, raspberries, and blackberries. In addition, a number of State Government Departments and natural resource management organizations provided support in both project activities and funding.

Program Management Costs

For the Hort Frontiers investment the cost of managing the Hort Innovation funding was added to the Hort Innovation contribution for the project via a management cost multiplier (1.143). 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 Annual Report, various years). This multiplier was then applied to the nominal investment by Hort Innovation shown in Table 2.

Real Investment and Extension Costs

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2021/22-dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022). The PH16004 project included a substantial allocation of resources for extension, appropriate materials were produced and communicated to horticultural growers, broadacre croppers, and beekeepers. No additional extension costs were incurred to secure forecast impacts.

Impacts

Table 4 provides a summary of the principal types of impacts delivered by the project, based on the logical framework (Table 2). Impacts have been categorised into economic, environmental, and social impacts.

Table 4: Triple Bottom Line Categories of Principal Impacts from Project PH16004

Economic	• Progress toward increased enterprise returns with improved pollination, average crop yield and quality for some crops in some locations. • Potential for reduced crop yield loss with Varroa mite (or a similar honey bee pest e.g., tropilaelaps) establishing in Australia. • Spill-over benefits including shade/shelter for livestock, and erosion control following the planting of native vegetation to encourage pollinators.
Environmental	• Additional biodiversity within the farm environment e.g., additional native pollinators and the presence of native birds and small mammals which feed on pollinators and additional populations of other insects. • Increased carbon sequestration with an increase in revegetated land and native vegetation managed for pollination.
Social	• Additional skills in understanding and managing pollinators. Skills developed by researchers (including postgraduate, PhD, and post-doctoral training) and growers (planting and vegetation management for pollination). • A repository of DNA data in SA on crop pollinating bees, and pollen types. Data available as an aid to future research. • Contribution to improved regional community wellbeing from spill-over income and employment benefits as a result of more productive and profitable agricultural industries.

Public versus Private Impacts

The impacts identified from the investment are both private and public in nature. Private impacts mostly accrue to growers (improved pollination, other farm benefits associated with shelter belts and erosion mitigation). Public impacts include gains for biodiversity, carbon sequestration, research/industry capacity, and spill-overs to regional communities from enhanced crop grower productivity and profit.

Distribution of Private Impacts

Private impacts will be captured by revegetation service providers, seed crop producers, crop growers, produce supply chain partners, and consumers.

Impacts on Other Australian Industries

While this project has focused on nine crops in specific locations, the principles established (e.g., native vegetation to improve pollination) will be applicable to other pollination dependent crops in other locations. It has been estimated that there are at least 35 different crops dependent on insect pollination in Australia.

Impacts Overseas

PH16004 findings are consistent with best-practice pollination in Europe and the United States. Provision of an evidence base for Australia may encourage growers of these same crops in Southern Africa and South America to adopt revegetation/native vegetation management for improved pollination.

Match with National Priorities

The Australian Government's National Science and Research Priorities and National Agricultural Innovation Priorities are reproduced in Table 5. The project outcomes and related impacts will contribute to National Science and Research Priority 1 and National Agricultural Innovation Priority 3.

Table 5: Australian Government Research Priorities

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

Alignment with the Hort Frontiers Pollination Fund Strategic Priorities

The Hort Frontiers Pollination Fund has three key investment themes defined by the Hort Innovation's Co-Investment Strategic Intent: Pollination document (Hort Innovation, 2018):

1) Manage European honey bee
2) Optimise crop pollination efficiency
3) Identify alternate crop pollinators

Project PH16004 directly delivered against theme 2 with some contribution to theme 1 and 3.

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[1] See: 2015 Australian Government Science and Research Priorities. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

[2] See: 2021 National Agriculture Innovation Policy Statement. https://www.awe.gov.au/agriculture-land/farm-food-drought/innovation/research_and_development_corporations_and_companies#government-priorities-for-investment

Case Study

The following SA case study was just one part of the project – field sites were also established in other states.

R&D CASE STUDY:
GROWER ENGAGEMENT IN POLLINATOR MANAGEMENT

THE CHALLENGE

Long established broadacre cropping and orcharding regions lack native vegetation to support unmanaged pollinators. Growers currently relying on unmanaged honey bees for crop pollination will experience yield loss if Varroa establishes and initiatives are not in place to support native insects.

MEET SIMON

Simon Anderson grows 1,300 ha of wheat, lentils and canola on his Yorketown property, Yorke Peninsula SA. A phone interview was completed with Simon, 11 July 2022. “The Securing Pollination project planted 0.5 ha of tube and seed stock on unutilised land on my property in August 2018. It was a little late in the year and was followed by a harsh spring. The aerially sown seed did not do well but the tube stock has been a big success. A diverse habitat has been established. While it is too early to say whether the revegetation will improve the pollination of my canola crop, the restored habitat is visually appealing and subsequent investigations by the university have shown that it is ideal for the planned introduction of a conical snail biocontrol. Planned introduction of a fly for conical snail control requires an area of multi-story vegetation near the crop. The area revegetated through Securing Pollination is ideal. An effective biocontrol for conical snail would have a positive impact on the profitability of my cropping operations”.

Simon went on to explain that other areas revegetated by the project have done even better than his farm, e.g., Jane Greenslade’s broadacre property at Maitland SA, where seed and tube stock were successful.

PH16004 Planting Team York Peninsula (canola) 2018 (photo credit Whitehouse 2021)

MEET JANE

Jane Greenslade, farmer, Maitland SA noted "The project (PH16004) did a fantastic job planting out 1,000 different plants. We've had great establishment. Plants have flowered this last spring and the planting has motivated me to continue to plant out that section of scrub for pollinators. If you are ever over this way, you really should have a look" (Whitehouse 2021).

PH16004 Planting Team Maitland (canola) 2019 (photo credit Whitehouse 2021)

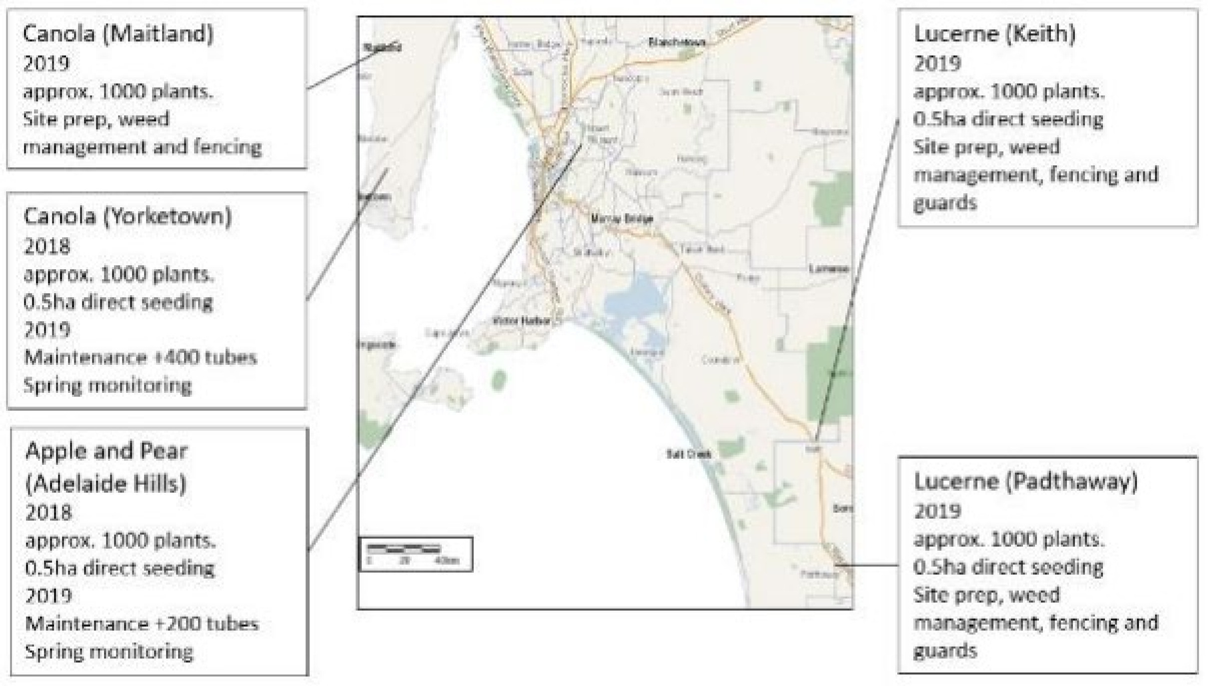
MEET KATJA

Dr Katja Hogendoorn, PH16004 Principal Investigator, noted that revegetation for both lucerne seed and apple growing had been successful. However, success with the Adelaide Hills apple orchard was subsequently negated by weeds, kangaroos, feral deer, and drought.

PH16004 Planting Team Adelaide Hills (apple) 2018 (photo credit Whitehouse 2021)

THE APPROACH

Each of the plantings involved around 20 volunteers, many from the local community. At each site approximately 1,000 tube stock of a diverse range of species were planted.



Canola (Maitland)
2019
approx. 1000 plants.
Site prep, weed management and fencing

Canola (Yorketown)
2018
approx. 1000 plants.
0.5ha direct seeding
2019
Maintenance +400 tubes
Spring monitoring

Apple and Pear (Adelaide Hills)
2018
approx. 1000 plants.
0.5ha direct seeding
2019
Maintenance +200 tubes
Spring monitoring

Lucerne (Keith)
2019
approx. 1000 plants.
0.5ha direct seeding
Site prep, weed management, fencing and guards

Lucerne (Padthaway)
2019
approx. 1000 plants.
0.5ha direct seeding
Site prep, weed management, fencing and guards

PH16004 Pollinator habitat developed by the project in apple, canola, and lucerne agricultural regions of SA (Whitehouse 2021)

THE IMPACT

In 2022 it is still too early to judge the impact of revegetation on pollination success (Dr Katja Hogendoorn, PH16004 Principal Investigator, pers. comm., July 2022).

Valuation of Impacts

Impacts Not Valued

Not all the impacts identified in Table 4 could be valued in the assessment. Those not valued included:

- Additional enterprise returns and yield loss savings for crops other than the nine included in the oroject. ABARES 2012 identified 35 Australian crops with some dependence on honey bee pollination.
- Spill-over benefits for landholders including shade/shelter for livestock and erosion control.
- Additional biodiversity and carbon sequestration associated with revegetation.
- Enhanced future capacity in scientific research and crop producer skills.
- Contribution to improved regional community wellbeing from spill-over income and employment benefits.

These impacts were not valued due to lack of data to support credible assumptions as well as the need to limit project scope to those crops most likely to benefit from project investment.

Impacts Valued

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.

Two impacts were valued:

- Increased enterprise returns with improved pollination.
- Reduced crop yield loss with Varroa mite incursion/establishment.

Impact 1: Increased Enterprise Returns with Improved Pollination

The potential impact of PH16004 on increased enterprise returns was assessed for all nine project crops. Crop production and performance data used for valuation is summarised in Table 6.

Table 6: Assumptions for Production and Performance of Nine Crops

Crop	Area (ha)	Production (tonnes)	Yield (t/ha)	Farmgate Value ($/kg)	Total Farmgate Value ($)	% Farmgate Value that is Profit#
Almond	31,165	89,755	2.88	8.42	756,000,000	15%
Apple	6,563	288,960	30.00	1.72	497,900,000	15%
Blueberry	1,375	16,850	12.25	17.6	309,000,000	15%
Canola	1,893,000	241,000	1.18	0.45	1,008,450,000	15%
Lucerne seed	16,000	8,000	0.50	4.20	33,600,000	15%
Mango	6,368	83,315	13.10	2.45	204,121,750	15%
Melon	8,500	217,000	25.00	0.44	95,480,000	15%
Pear	4,368	102,000	23.40	1.56	107,000,000	15%
Raspberry	613	6,189	10.10	25.4	157,300,000	15%

Sources: Hort Innovation 2022, Lucerne Australia, and Apple & Pear Australia Limited websites.
Farmgate profit was estimated from the Australian National Accounts: Input-Output Tables 2020-21 (ABS 2023), for agricultural production (gross operating surplus after allowing for all costs of production but prior to allowance for taxation) and cross checked with available enterprise gross margins (e.g., QDAF mango production). NB: gross margins do not allow for the cost of farm capital.

Proportion of existing crop area subject to revegetation management
In the absence of alternative data and after discussions with the project Principal Investigator Dr Katja Hogendoorn, the proportion of existing crop area subject to revegetation was estimated at 10% for all nine crops.

Revegetation costs
The minimum cost to revegetate land is estimated in the PH16004 final report at more than $25,000/ha for the creation of high diversity habitat. However, it is noted that improvements to native vegetation management are undertaken for a variety of reasons and are driven by a range of factors including industry and local and state government policies such as carbon sequestration, biodiversity enhancement, wildlife habitat restoration and wildlife corridors, and various other land management imperatives. The project legacy implication here is that the improved knowledge of pollination enhancement produced by the project could be incorporated into future revegetation initiatives that would occur anyway, thus considerably lowering the cost per hectare of any pollination enhancement gained. A low/no opportunity cost of this land has also been assumed (see above case study).

Furthermore, it is noted that revegetation may not be required for growers to realise PH16004 impacts. Existing native trees, shrubs, and grasses might simply be set aside. In other instances, a valid response might be as simple as construction of a native bee “hotel” from a bunch of sticks. For these reasons a lower cost estimate of $500/ha as a one off capital cost or $5/ha/year has been used in the analysis.

Ratio of crop area benefiting to revegetation area
The estimate for this parameter is important to relate the cost of revegetation to the area of crop likely to benefit. For all crops the assumption is made that one hectare of revegetation is required to benefit one hectare of crop. The estimate was made after considering information presented in project documentation and discussion with project Principal Investigator Dr Katja Hogendoorn.

Estimated pollination efficiency increase due to revegetation management
A 15% increase in pollination efficiency is assumed for all nine crops where vegetation and the pollinator environment has been enhanced. Once again, the assumption was made after review of project documentation and discussion with project Principal Investigator Dr Katja Hogendoorn.

Estimated crop yield/quality increase due to pollination efficiency increase
The conversion of the pollination efficiency gain to a crop yield/quality gain is assumed to be one, i.e., a 15% gain in pollination efficiency equates to a 15% gain in crop yield/quality (a 100% conversion factor). The estimate is made noting that pollination is only one factor affecting yield and that other inputs and conditions including nutrition, water, farmer skill, and variations in the weather, all impact crop production.

Time lag from revegetation to crop impact
A time lag of 5 years from the first year of revegetation/improvement in the pollinator environment is assumed.

Impact 2: Reduced Crop Yield Loss with Varroa Mite Incursion/Establishment

PH16004 is likely to have an impact on the costs of managing the potential impact of Varroa mite following incursion and establishment in Australia. The impact is valued with reference to a 2012 Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) study that simulated the hypothetical spread of Varroa from Australian ports over a 30-year period (ABARES 2012). The simulations were used to estimate the potential economic losses from the assumed Varroa incursion by valuing the effect on production, prices, consumption, imports, and exports of 35 pollination-dependent crops, as well as on the demand for, and supply of services, by the managed pollination industry. The study reported that if the spread could be slowed through containment, the losses were estimated at a present value of $0.36 billion to $0.93 billion, depending on the port of entry. These estimates were estimated over 30 years from the year of incursion and were expressed in 2012-dollar terms.

The baseline estimate of impact costs was used in the current analysis by assuming the current project (PH16004) would contribute to a 10% reduction in these potential future losses and expressing the loss in 2021/22-dollar terms. A 10% reduction in potential future loss was made by the analyst in the absence of alternative data and is tested using sensitivity analysis. It is noted that total loss estimates caused by a possible Varroa mite incursion and establishment may be conservative given growth in the value of all crops, and especially horticulture, over the last decade.

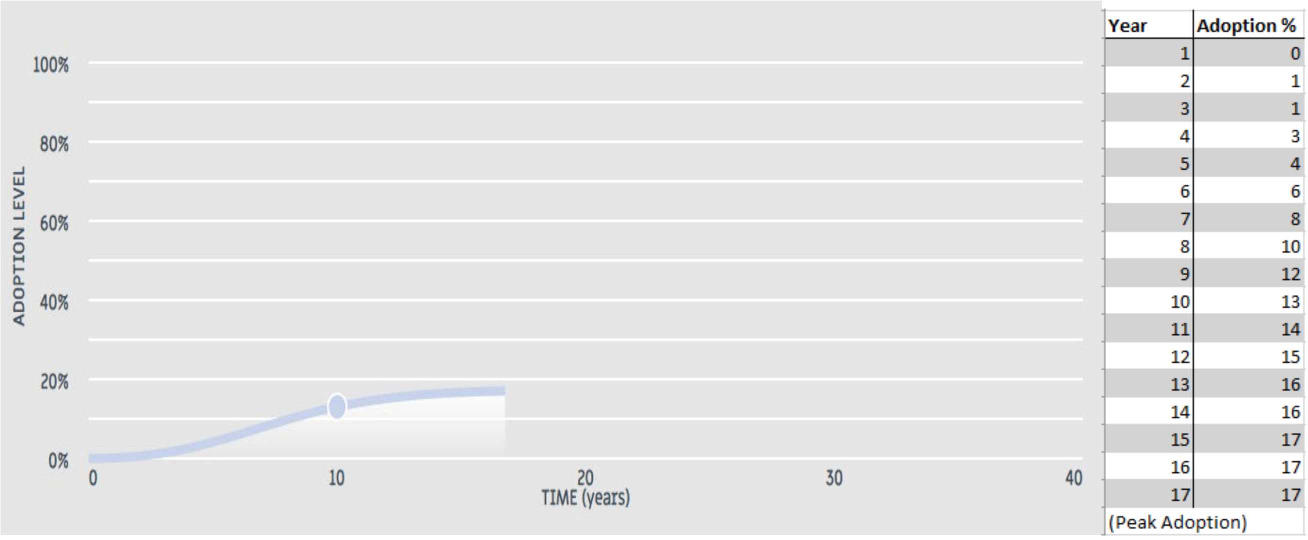
CSIRO Adopt Model Insights

Project parameters were entered into the CSIRO Adopt Model. Assumptions, inputs and outputs used are detailed in Appendix 1. Adopt Model results were:

- Time to peak adoption: 17 years.
- Peak adoption level: 17%.
- In 5 years from start: 4% of the population will have adopted. The population has been defined as Australian crop growers.
- In 10 years from start: 13% of the population will have adopted.
- Time to reach 50% of peak adoption: 7.4 years.

The adoption profile and levels modelled using the CSIRO Adopt Tool are shown in Figure 1 below. These insights were considered when preparing valuation assumptions.

Figure 1: CSIRO Adopt Model, Adoption Level S-Curve for PH16004



Year	Adoption %
1	0
2	1
3	1
4	3
5	4
6	6
7	8
8	10
9	12
10	13
11	14
12	15
13	16
14	16
15	17
16	17
17	17
(Peak Adoption)	

Summary of Assumptions

Table 7 contains a summary of other assumptions required for estimation of both quantified impacts.

Table 7: Summary of Additional Assumptions for Impact Valuation

Variable	Assumption/Value	Source/Comment
Year of first impact.	2027/28.	Assumes revegetation / improvement in the pollinator environment commences in 2022/23 and five years is required before the initiative attracts additional pollinators.
Attribution of impacts to this project.	100%	PH16004 final report notes that this project was the first in Australia to determine the ways in which growers can harness the pollination capacity of native and exotic pollinators in an integrated way.
Probability of the project generating useful outputs.	100%	Outputs have been delivered – benefits of environmental improvement to native and exotic pollinators have been shown.
Probability of valuable outcomes.	75%	There is some risk that adoption of revegetation/pollinator habitat will not occur.
Probability of impact (assuming successful outcome)	75%	There is some risk that yield/quality will not increase and Varroa containment will not occur.
Counterfactual.	85%	In the absence of PH16004 it is possible that the results would have been generated by another project.

Results

All costs and benefits were discounted to 2022/23 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 (2020/21) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Table 8 and Table 9 show the investment criteria estimated for different periods of benefits for the total investment and Hort Frontiers investment. Hort Frontiers present value of benefits (Table 8) was estimated by multiplying the total present value of benefits by the Hort Frontiers proportion of total undiscounted costs expressed in 2021/22-dollar terms.

Table 8: Investment Criteria for Total Investment in Project PH16004

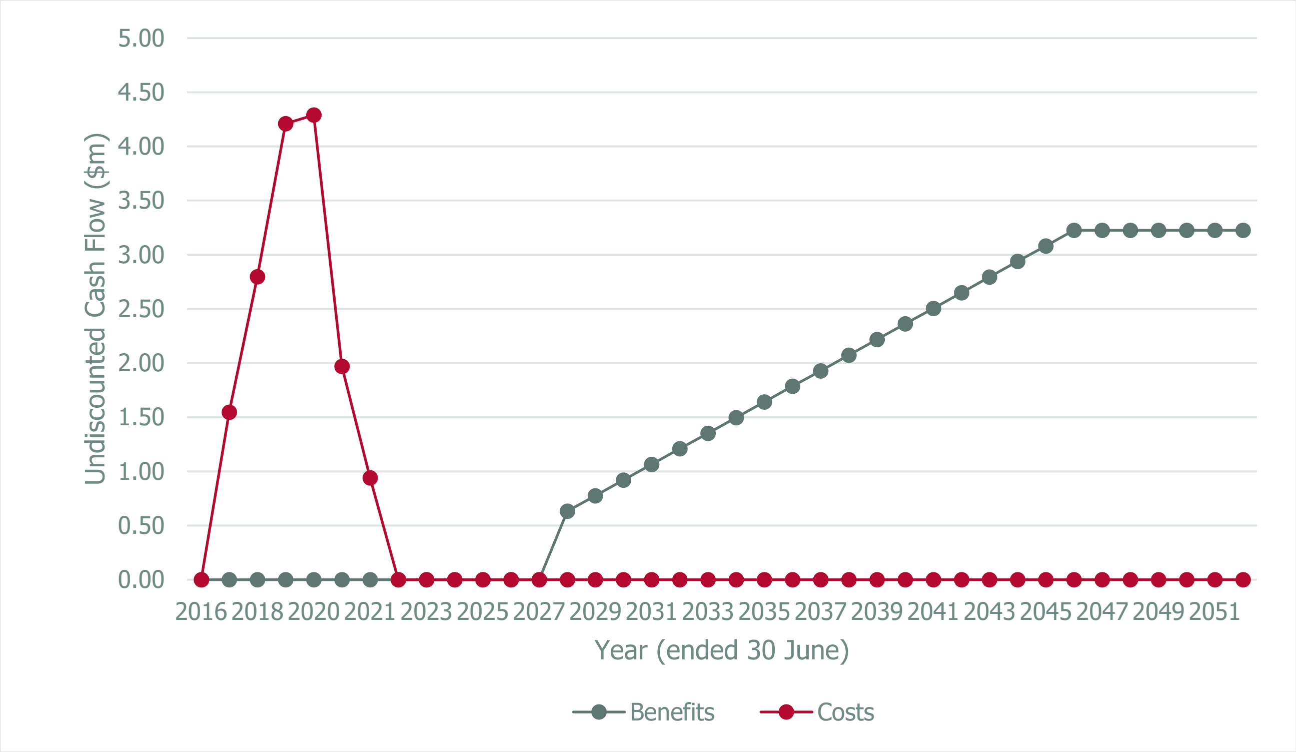
Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.00	3.23	7.77	12.90	18.11	22.44
Present Value of Costs ($m)	19.83	19.83	19.83	19.83	19.83	19.83	19.83
Net Present Value ($m)	-19.83	-19.83	-16.60	-12.06	-6.93	-1.72	2.61
Benefit-Cost Ratio	0.00	0.00	0.16	0.39	0.65	0.91	1.13
Internal Rate of Return (%)	negative	negative	negative	negative	1.5	4.1	5.4
MIRR (%)	negative	negative	negative	negative	2.5	4.4	5.3

Table 9: Investment Criteria for Hort Innovation Managed Investment in Project PH16004

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.00	0.58	1.40	2.32	3.25	4.03
Present Value of Costs ($m)	3.56	3.56	3.56	3.56	3.56	3.56	3.56
Net Present Value ($m)	-3.56	-3.56	-2.98	-2.17	-1.24	-0.31	0.47
Benefit-Cost Ratio	0.00	0.00	0.16	0.39	0.65	0.91	1.13
Internal Rate of Return (%)	negative	negative	negative	negative	1.5	4.1	5.4
MIRR (%)	negative	negative	negative	negative	2.5	4.4	5.3

The annual undiscounted benefit and cost cash flows for the total investment for the duration of the PH16004 investment plus 30 years from the last year of investment are shown in Figure 2.

Figure 2: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs



Source of benefits

Table 10 shows the contribution to total benefits from each of the two benefits valued. The increased enterprise returns with improved pollination benefit spread across nine crops was the principal contributor.

Table 10: Source of Total Benefits
(Total investment, 30 years)

Impact	**Contribution to PVB ($m)**	**Share of Total Benefits (%)**
Impact 1: Increased enterprise returns with improved pollination	18.45	82.2
Impact 2: Reduced crop yield loss with Varroa incursion/establishment	3.99	17.8
Total	**22.44**	**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. The results are sensitive to the discount rate. At a discount rate of 10% estimated project benefits do not cover project costs.

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

Investment Criteria	Discount Rate		
	0%	**5% (base)**	**10%**
Present Value of Benefits ($m)	56.01	22.44	10.36
Present Value of Costs ($m)	15.75	19.83	24.79
Net Present Value ($m)	40.25	2.61	-14.43
Benefit-cost ratio	3.56	1.13	0.42

A sensitivity analysis was then undertaken on the pollination efficiency gain attributable to adoption of project recommendations. Results are provided in Table 12. When assumed gain in pollination efficiency is reduced to 10%, and all other factors remain unchanged, project costs exceed project benefits.

Table 12: Sensitivity to Gain in Pollination Efficiency from PH16004 Adoption
(Total investment, 30 years)

Investment Criteria	Gain in Pollination Efficiency		
	10%	**15% (base)**	**20%**
Present Value of Benefits ($m)	15.29	22.44	29.60
Present Value of Costs ($m)	19.83	19.83	19.83
Net Present Value ($m)	-4.54	2.61	9.77
Benefit-cost ratio	0.77	1.13	1.49

A final sensitivity analysis tested assumed reduction in crop yield loss associated with Varroa with adoption of PH16004 recommendations. The results (Table 13) show that if the reduction in yield loss is only 5%, and all other factors remain unchanged, then investment in the project will “breakeven”.

Table 13: Sensitivity to Reduction in Varroa Linked Crop Yield Loss with PH16004 Adoption
(Total investment, 30 years)

Investment Criteria	Reduction in Crop Yield Loss		
	5%	**10% (base)**	**15%**
Present Value of Benefits ($m)	20.45	22.44	24.44
Present Value of Costs ($m)	19.83	19.83	19.83
Net Present Value ($m)	0.62	2.61	4.61
Benefit-cost ratio	1.03	1.13	1.23

Confidence Rating

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

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 14). 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 14: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
High	Low

Coverage of benefits valued was assessed as High, the key impact (additional pollination) and a secondary impact (reduced cost of Varroa management) were valued. Confidence in assumptions was rated as Low, key data were estimated by the analyst.

Conclusions

The project (PH16004) has contributed to a larger RND4P project and delivered progress toward improved crop pollination, produce quality, and yield. Project costs were large and upfront while benefits are likely to be concentrated in the future, rather than the near-term. Consequently, return on investment is modest.

Total funding from all sources for the project was $19.83 million (present value terms). The investment produced estimated total expected benefits of $22.44 million (present value terms). This gave a net present value of $2.61 million, an estimated benefit-cost ratio of 1.13 to 1, an internal rate of return of 5.4% and a modified internal rate of return of 5.3%.

As one economic, one environmental and two social impacts were not valued, the investment criteria estimated by the evaluation may be underestimates of the actual performance of the investment.

Recommendations

Impact assessment is now a mature process within Hort Innovation. No recommendations are made for further refinement.

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Acknowledgements

AgEconPlus 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 acknowledgements:

- Simon Anderson, Broadacre Farmer, Yorketown, SA
- Paul Blackshaw, Project Manager, Securing Pollination, AgriFutures Australia
- Sarah Cumpston, Evaluation and Measurement Specialist, Hort Innovation
- Katja Hogendoorn, Principal Investigator Securing Pollination, University of Adelaide
- Ashley Zamek, R&D Manager, Hort Innovation

Abbreviations and Acronyms

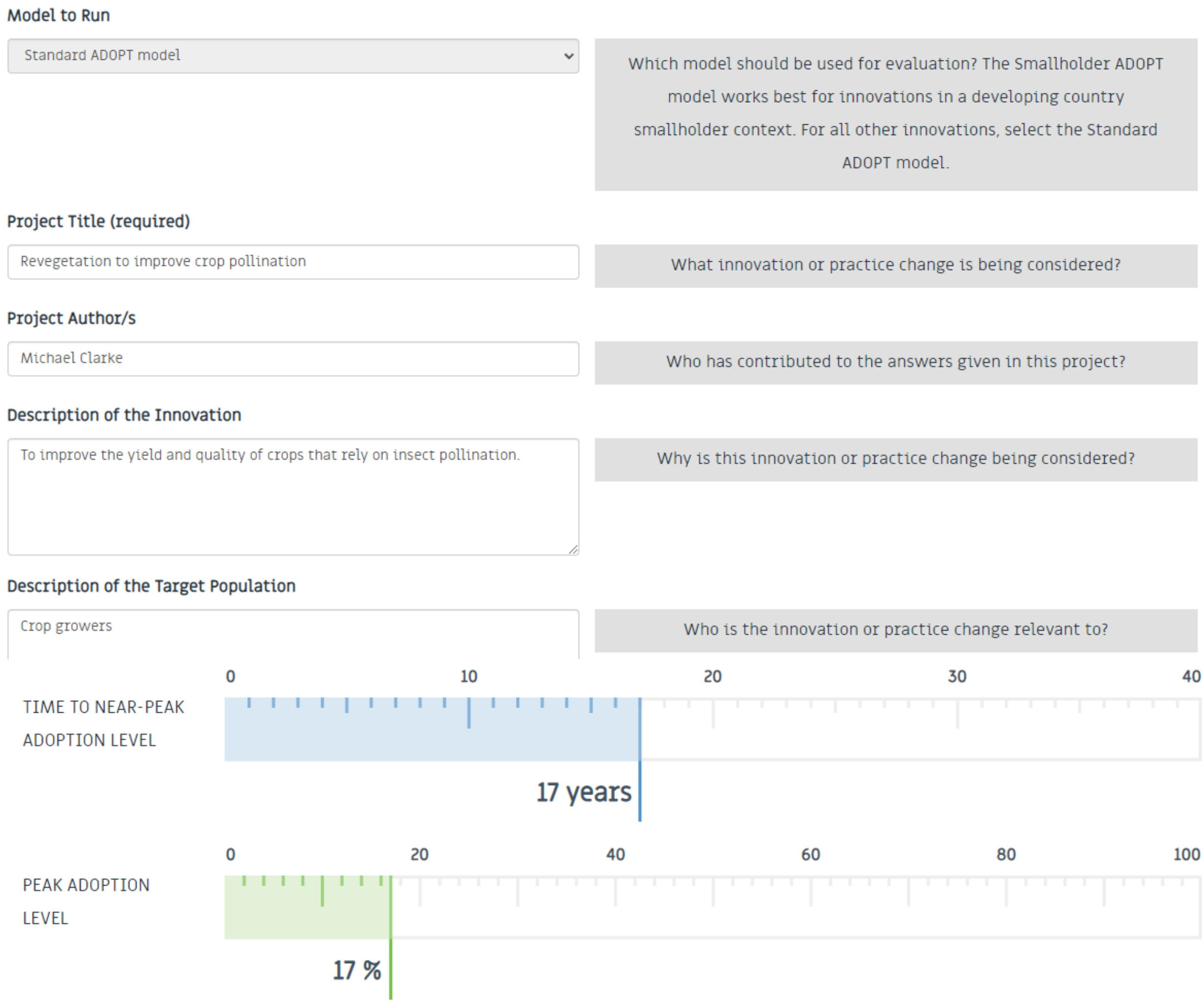
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ANU	Australian National University
CRRDC	Council of Research and Development Corporations
DAWR	Department of Agriculture and Water Resources (Australian Government)
GDP	Gross Domestic Product
GVP	Gross Value of Production
IRR	Internal Rate of Return
LOP	Life of Project
MIRR	Modified Internal Rate of Return
OCS	Office of Chief Scientist Queensland
PIRSA	Primary Industries and Resources South Australia
PVB	Present Value of Benefits
R&D	Research and Development
RD&E	Research, Development and Extension
SA	South Australia
UNE	University of New England
USYD	University of Sydney

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.

Appendix 1: CSIRO Adopt Model Detailed Assumptions, Inputs, and Outputs

Assumptions, inputs and outputs used to develop an adoption profile for PH16004 – Securing Pollination for a More Productive Agriculture are reproduced in this appendix.



Model to Run

Standard ADOPT model

Which model should be used for evaluation? The Smallholder ADOPT model works best for innovations in a developing country smallholder context. For all other innovations, select the Standard ADOPT model.

Project Title (required)

Revegetation to improve crop pollination

What innovation or practice change is being considered?

Project Author/s

Michael Clarke

Who has contributed to the answers given in this project?

Description of the Innovation

To improve the yield and quality of crops that rely on insect pollination.

Why is this innovation or practice change being considered?

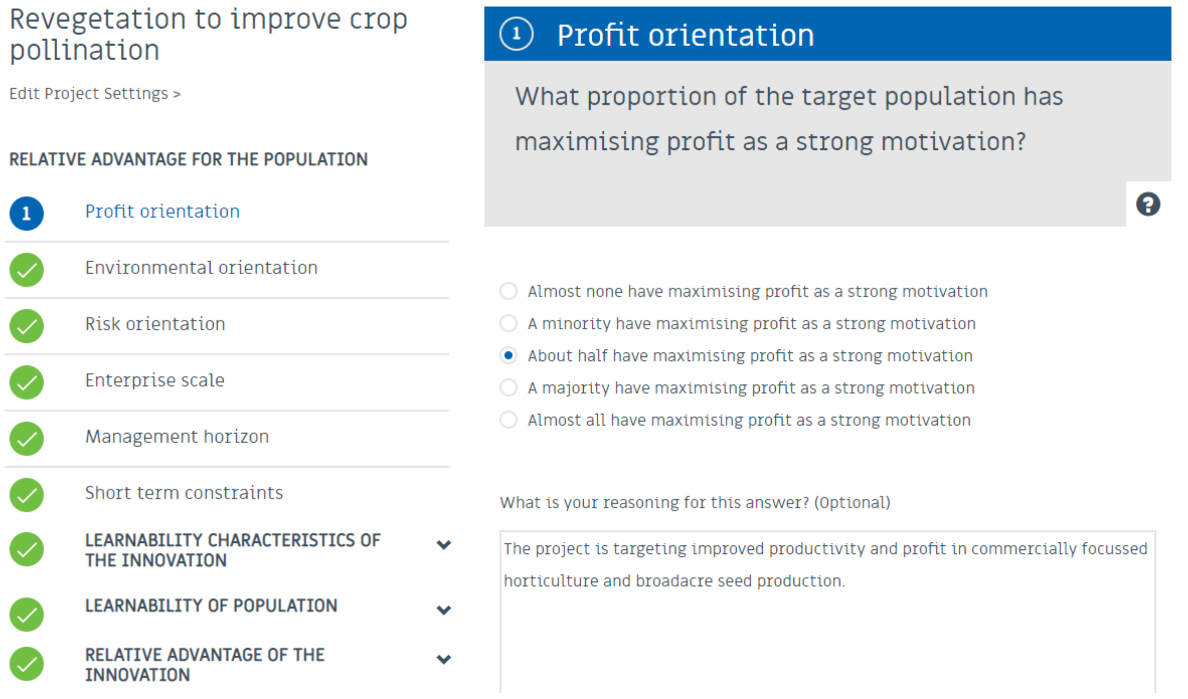
Description of the Target Population

Crop growers

Who is the innovation or practice change relevant to?

TIME TO NEAR-PEAK ADOPTION LEVEL: 17 years

PEAK ADOPTION LEVEL: 17 %



Revegetation to improve crop pollination

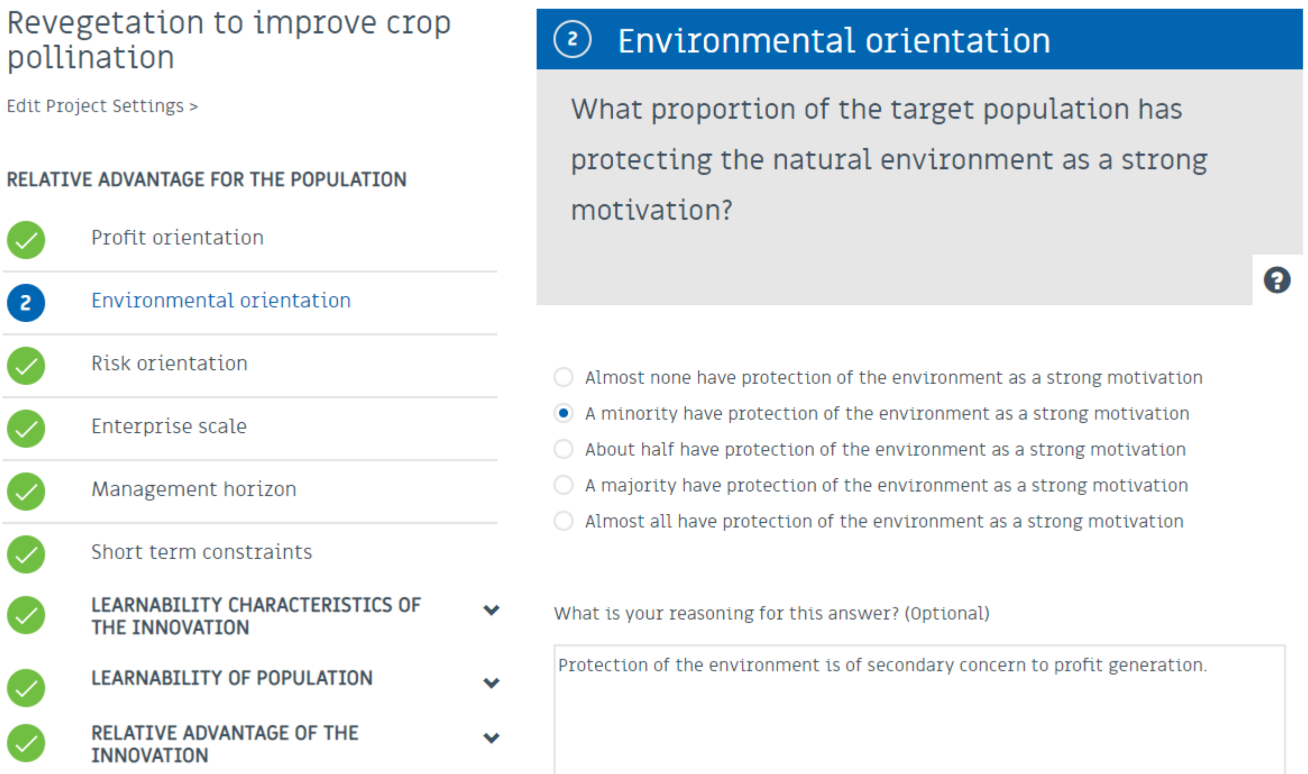
① Profit orientation

What proportion of the target population has maximising profit as a strong motivation?

○ Almost none have maximising profit as a strong motivation
○ A minority have maximising profit as a strong motivation
● About half have maximising profit as a strong motivation
○ A majority have maximising profit as a strong motivation
○ Almost all have maximising profit as a strong motivation

What is your reasoning for this answer? (Optional)

The project is targeting improved productivity and profit in commercially focussed horticulture and broadacre seed production.



Revegetation to improve crop pollination

Edit Project Settings >

RELATIVE ADVANTAGE FOR THE POPULATION

- ✓ Profit orientation
- 2 Environmental orientation
- ✓ Risk orientation
- ✓ Enterprise scale
- ✓ Management horizon
- ✓ Short term constraints
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION
- ✓ LEARNABILITY OF POPULATION
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

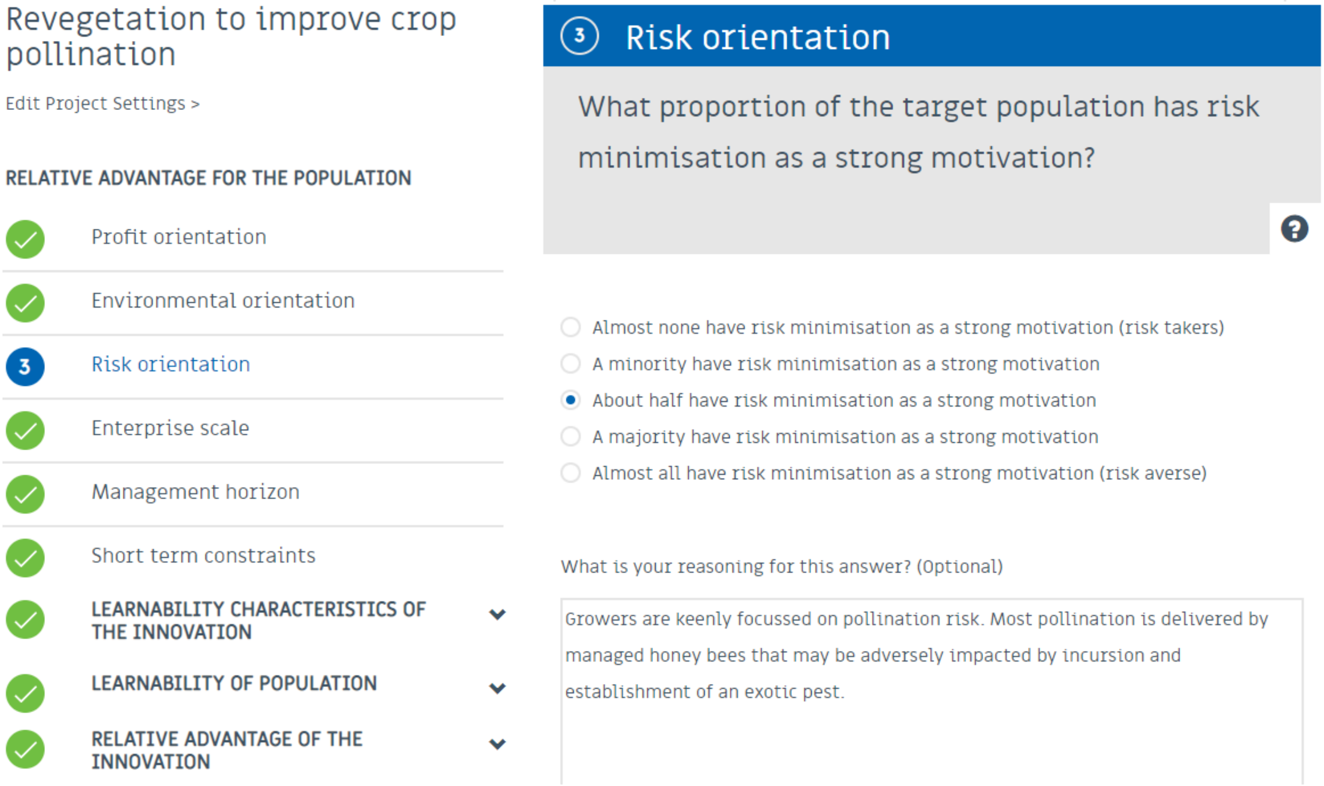
② Environmental orientation

What proportion of the target population has protecting the natural environment as a strong motivation?

- ○ Almost none have protection of the environment as a strong motivation
- ● A minority have protection of the environment as a strong motivation
- ○ About half have protection of the environment as a strong motivation
- ○ A majority have protection of the environment as a strong motivation
- ○ Almost all have protection of the environment as a strong motivation

What is your reasoning for this answer? (Optional)

Protection of the environment is of secondary concern to profit generation.



Revegetation to improve crop pollination

Edit Project Settings >

RELATIVE ADVANTAGE FOR THE POPULATION

- ✓ Profit orientation
- ✓ Environmental orientation
- 3 Risk orientation
- ✓ Enterprise scale
- ✓ Management horizon
- ✓ Short term constraints
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION
- ✓ LEARNABILITY OF POPULATION
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

③ Risk orientation

What proportion of the target population has risk minimisation as a strong motivation?

- ○ Almost none have risk minimisation as a strong motivation (risk takers)
- ○ A minority have risk minimisation as a strong motivation
- ● About half have risk minimisation as a strong motivation
- ○ A majority have risk minimisation as a strong motivation
- ○ Almost all have risk minimisation as a strong motivation (risk averse)

What is your reasoning for this answer? (Optional)

Growers are keenly focussed on pollination risk. Most pollination is delivered by managed honey bees that may be adversely impacted by incursion and establishment of an exotic pest.

Revegetation to improve crop pollination

Edit Project Settings >

RELATIVE ADVANTAGE FOR THE POPULATION

- ✓ Profit orientation
- ✓ Environmental orientation
- ✓ Risk orientation
- 4 Enterprise scale
- ✓ Management horizon
- ✓ Short term constraints
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION
- ✓ LEARNABILITY OF POPULATION
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

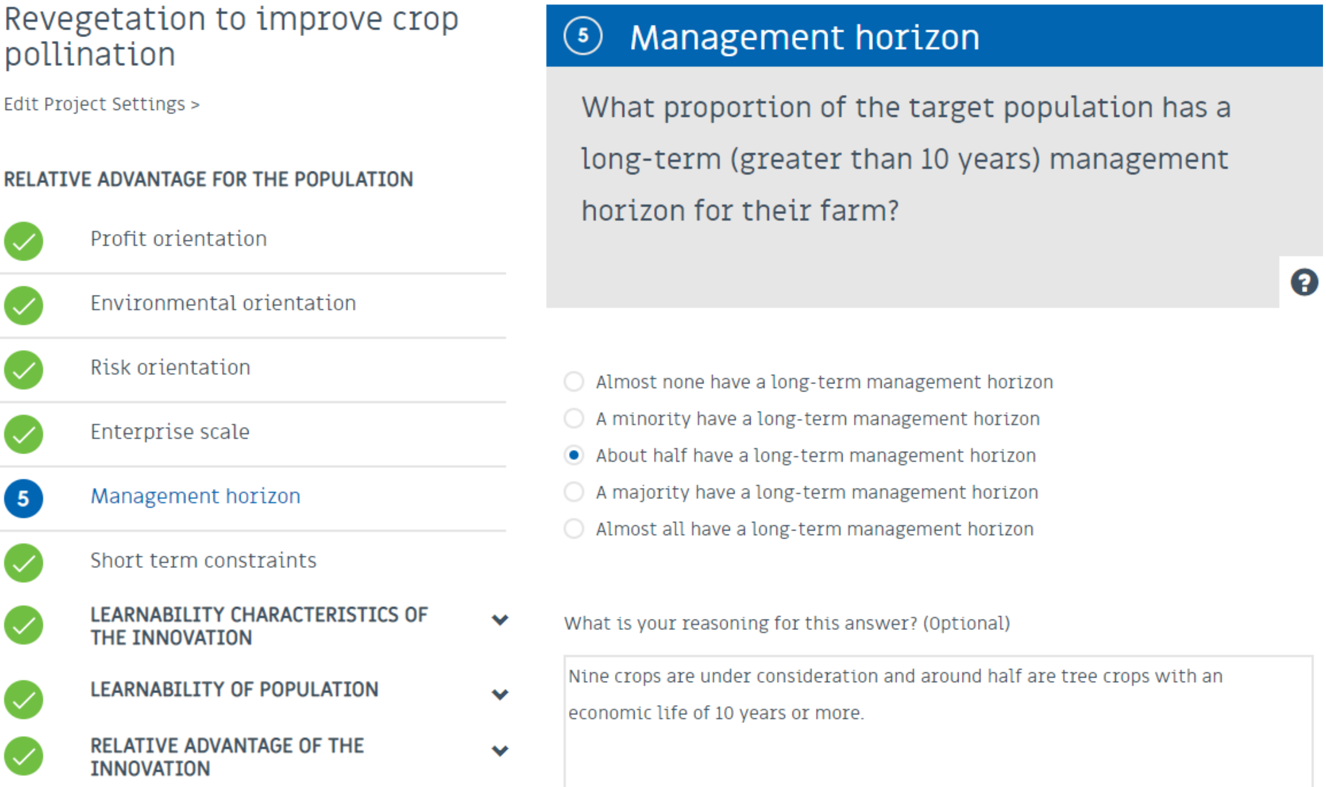
④ Enterprise scale

On what proportion of the target farms is there a major enterprise that could benefit from the innovation?

- ○ Almost none of the target farms have a major enterprise that could benefit
- ○ A minority of the target farms have a major enterprise that could benefit
- ● About half of the target farms have a major enterprise that could benefit
- ○ A majority of the target farms have a major enterprise that could benefit
- ○ Almost all of the target farms have a major enterprise that could benefit

What is your reasoning for this answer? (Optional)

Large corporates are present in each of the industries under consideration.



Revegetation to improve crop pollination

Edit Project Settings >

RELATIVE ADVANTAGE FOR THE POPULATION

- ✓ Profit orientation
- ✓ Environmental orientation
- ✓ Risk orientation
- ✓ Enterprise scale
- 5 Management horizon
- ✓ Short term constraints
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION
- ✓ LEARNABILITY OF POPULATION
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

⑤ Management horizon

What proportion of the target population has a long-term (greater than 10 years) management horizon for their farm?

- ○ Almost none have a long-term management horizon
- ○ A minority have a long-term management horizon
- ● About half have a long-term management horizon
- ○ A majority have a long-term management horizon
- ○ Almost all have a long-term management horizon

What is your reasoning for this answer? (Optional)

Nine crops are under consideration and around half are tree crops with an economic life of 10 years or more.

Revegetation to improve crop pollination

Edit Project Settings >

RELATIVE ADVANTAGE FOR THE POPULATION

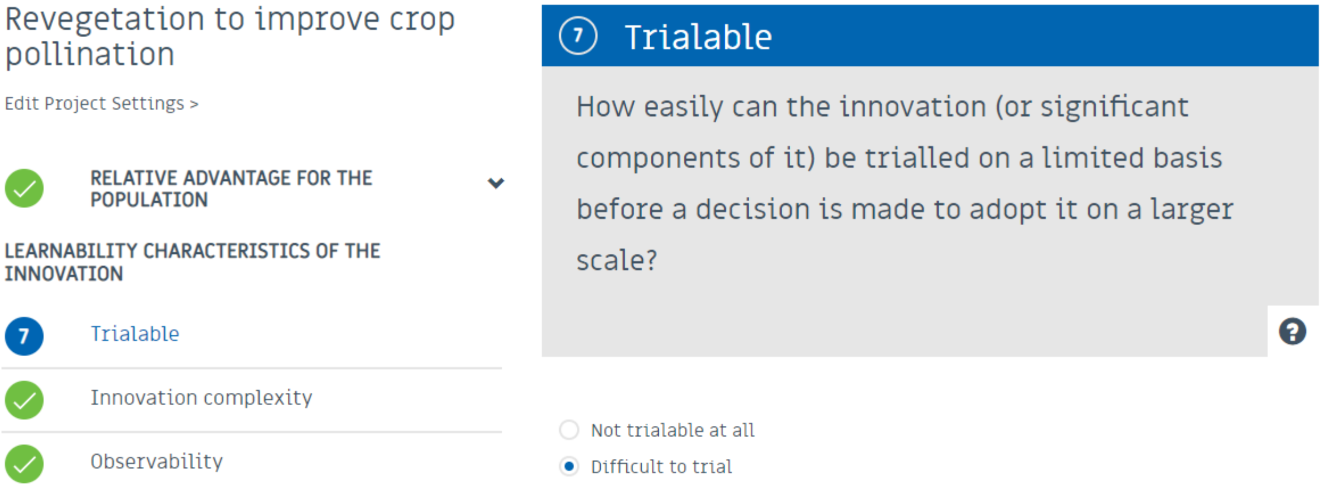
- ✓ Profit orientation
- ✓ Environmental orientation
- ✓ Risk orientation
- ✓ Enterprise scale
- ✓ Management horizon
- 6 Short term constraints

LEARNABILITY CHARACTERISTICS OF

⑥ Short term constraints

What proportion of the target population is under conditions of severe short-term financial constraints?

○ Almost all currently have a severe short-term financial constraint
○ A majority currently have a severe short-term financial constraint
● About half currently have a severe short-term financial constraint
○ A minority currently have a severe short-term financial constraint
○ Almost none currently have a severe short-term financial constraint



Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

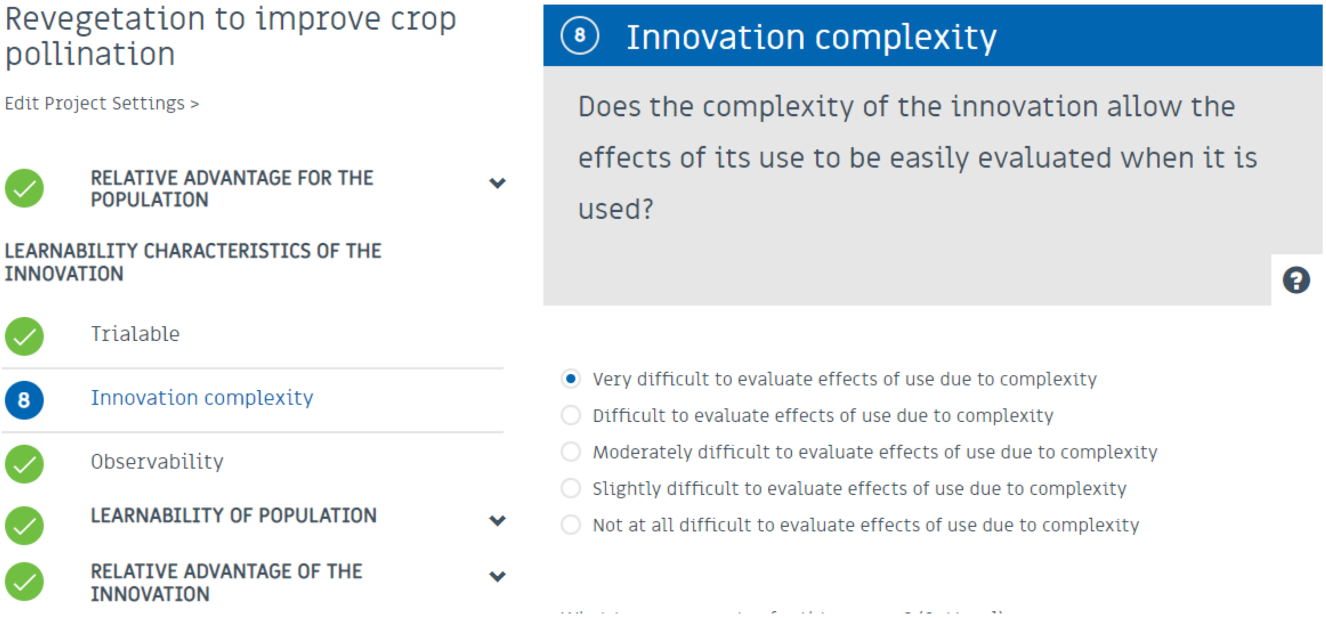
LEARNABILITY CHARACTERISTICS OF THE INNOVATION

- 7 Trialable
- ✓ Innovation complexity
- ✓ Observability

⑦ Trialable

How easily can the innovation (or significant components of it) be trialled on a limited basis before a decision is made to adopt it on a larger scale?

○ Not trialable at all
● Difficult to trial



Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

LEARNABILITY CHARACTERISTICS OF THE INNOVATION

- ✓ Trialable
- 8 Innovation complexity
- ✓ Observability

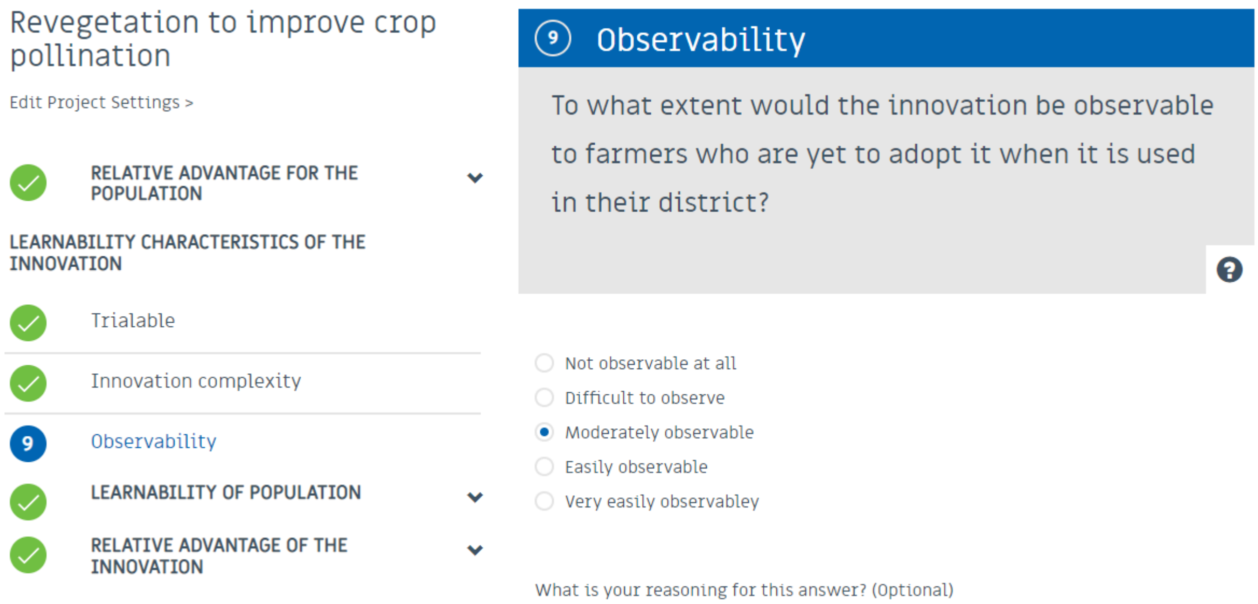
✓ LEARNABILITY OF POPULATION

✓ RELATIVE ADVANTAGE OF THE INNOVATION

⑧ Innovation complexity

Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?

● Very difficult to evaluate effects of use due to complexity
○ Difficult to evaluate effects of use due to complexity
○ Moderately difficult to evaluate effects of use due to complexity
○ Slightly difficult to evaluate effects of use due to complexity
○ Not at all difficult to evaluate effects of use due to complexity



Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ Trialable

✓ Innovation complexity

9 Observability

✓ LEARNABILITY OF POPULATION

✓ RELATIVE ADVANTAGE OF THE INNOVATION

9 Observability

To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district?

○ Not observable at all
○ Difficult to observe
● Moderately observable
○ Easily observable
○ Very easily observabley

What is your reasoning for this answer? (Optional)

Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

LEARNABILITY OF POPULATION

10 Advisory support

✓ Group involvement

✓ Relevant existing skills & knowledge

✓ Innovation awareness

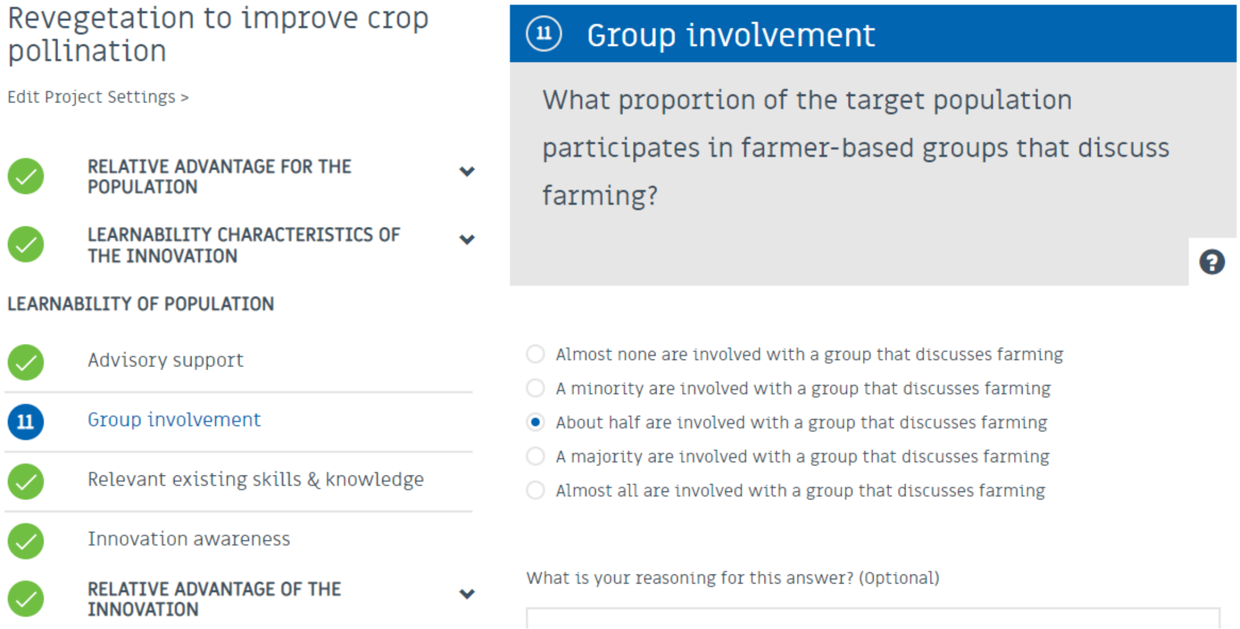
✓ RELATIVE ADVANTAGE OF THE INNOVATION

10 Advisory support

What proportion of the target population uses paid advisors capable of providing advice relevant to the project?

○ Almost none use a relevant advisor
○ A minority use a relevant advisor
● About half use a relevant advisor
○ A majority use a relevant advisor
○ Almost all use a relevant advisor

What is your reasoning for this answer? (Optional)



Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

LEARNABILITY OF POPULATION

✓ Advisory support

11 Group involvement

✓ Relevant existing skills & knowledge

✓ Innovation awareness

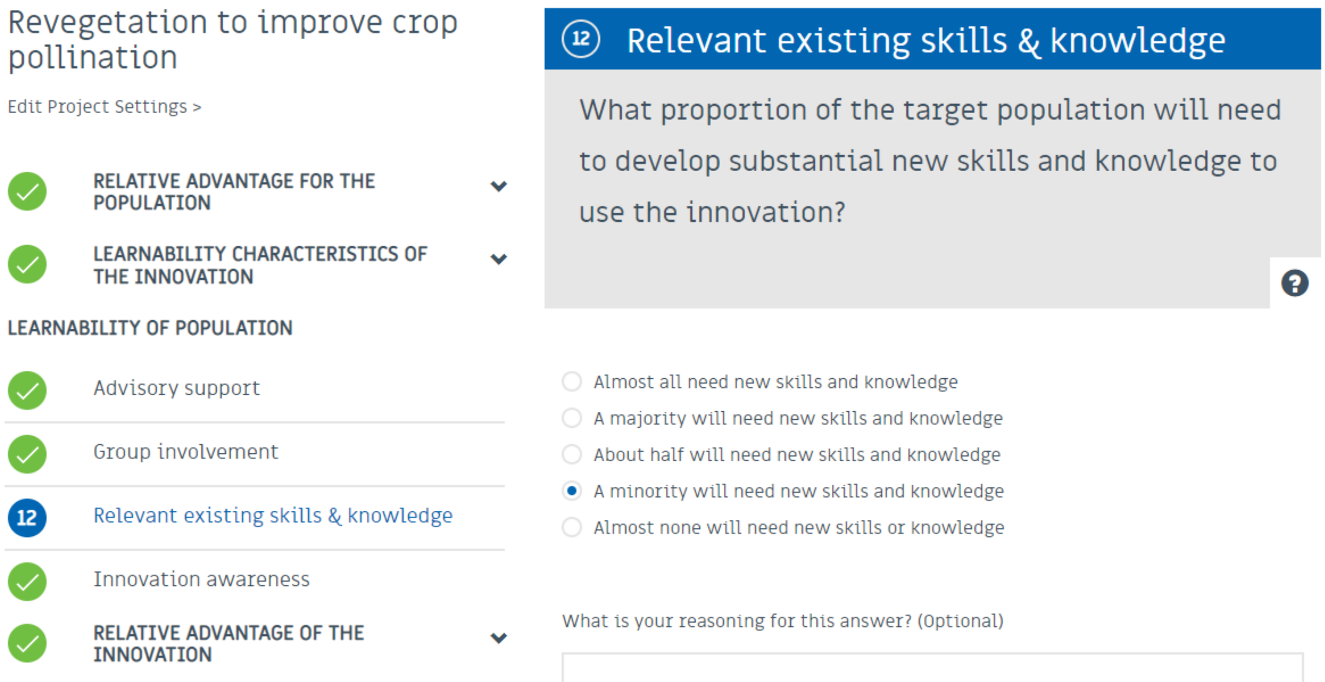
✓ RELATIVE ADVANTAGE OF THE INNOVATION

11 Group involvement

What proportion of the target population participates in farmer-based groups that discuss farming?

○ Almost none are involved with a group that discusses farming
○ A minority are involved with a group that discusses farming
● About half are involved with a group that discusses farming
○ A majority are involved with a group that discusses farming
○ Almost all are involved with a group that discusses farming

What is your reasoning for this answer? (Optional)



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- ✓ RELATIVE ADVANTAGE FOR THE POPULATION
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

LEARNABILITY OF POPULATION

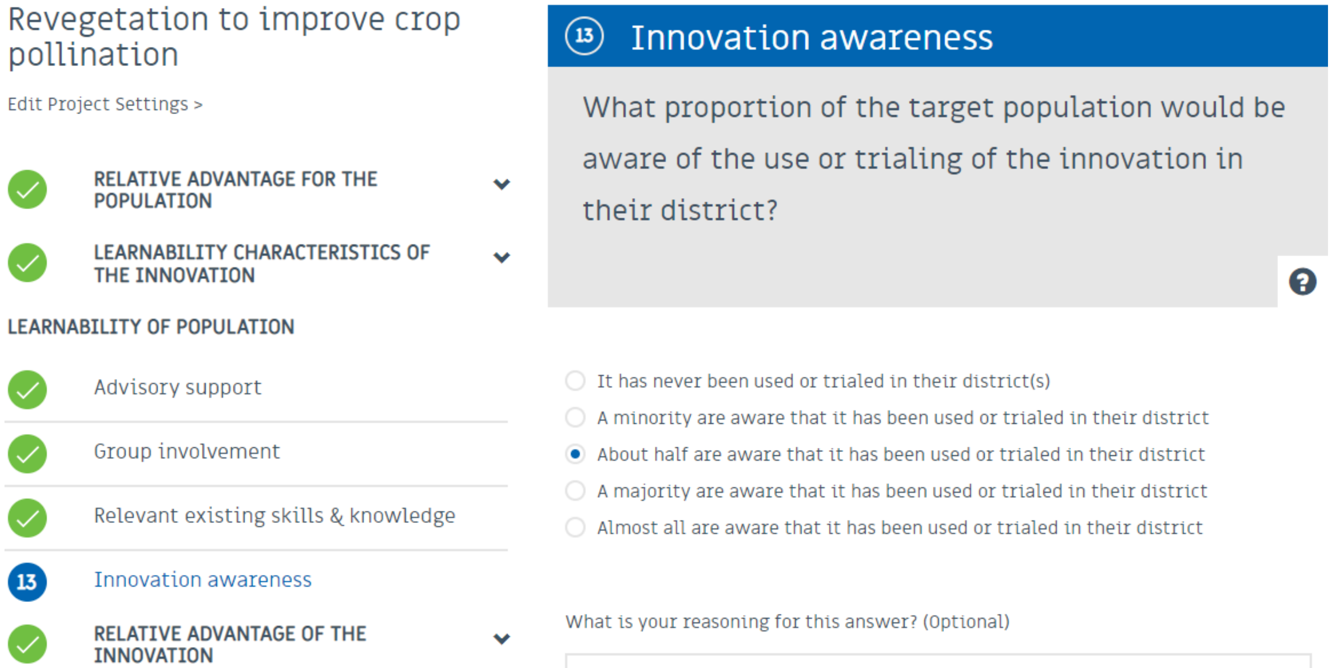
- ✓ Advisory support
- ✓ Group involvement
- 12 Relevant existing skills & knowledge
- ✓ Innovation awareness
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

⑫ Relevant existing skills & knowledge

What proportion of the target population will need to develop substantial new skills and knowledge to use the innovation?

- ○ Almost all need new skills and knowledge
- ○ A majority will need new skills and knowledge
- ○ About half will need new skills and knowledge
- ● A minority will need new skills and knowledge
- ○ Almost none will need new skills or knowledge

What is your reasoning for this answer? (Optional)



Revegetation to improve crop pollination

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- ✓ RELATIVE ADVANTAGE FOR THE POPULATION
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

LEARNABILITY OF POPULATION

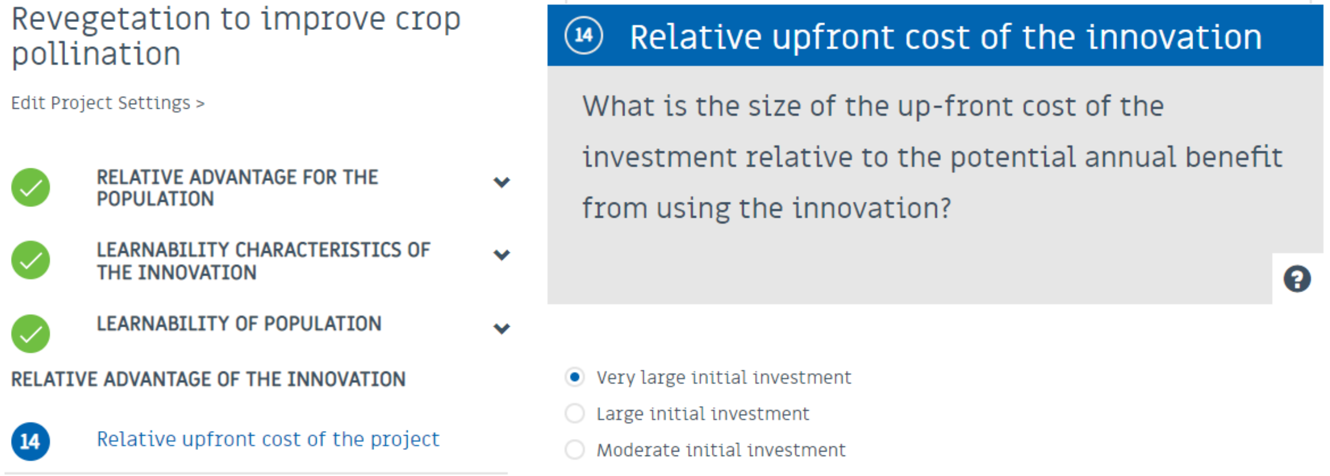
- ✓ Advisory support
- ✓ Group involvement
- ✓ Relevant existing skills & knowledge
- 13 Innovation awareness
- ✓ RELATIVE ADVANTAGE OF THE INNOVATION

⑬ Innovation awareness

What proportion of the target population would be aware of the use or trialing of the innovation in their district?

- ○ It has never been used or trialed in their district(s)
- ○ A minority are aware that it has been used or trialed in their district
- ● About half are aware that it has been used or trialed in their district
- ○ A majority are aware that it has been used or trialed in their district
- ○ Almost all are aware that it has been used or trialed in their district

What is your reasoning for this answer? (Optional)



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- ✓ RELATIVE ADVANTAGE FOR THE POPULATION
- ✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION
- ✓ LEARNABILITY OF POPULATION

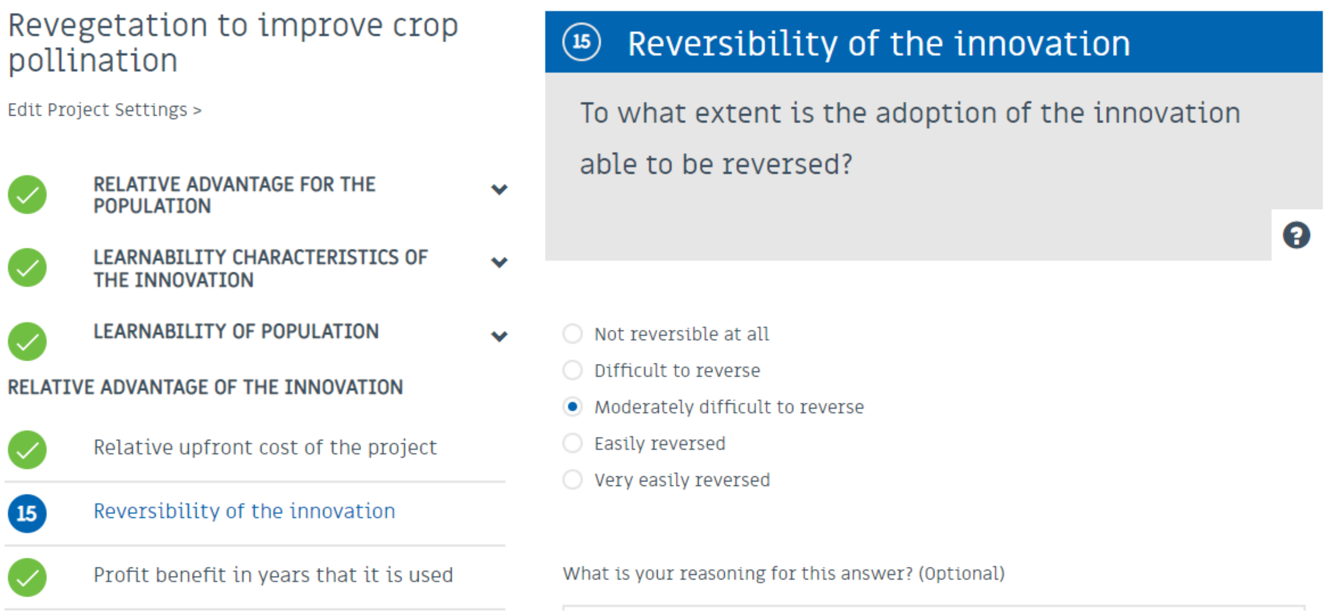
RELATIVE ADVANTAGE OF THE INNOVATION

- 14 Relative upfront cost of the project

⑭ Relative upfront cost of the innovation

What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation?

- ● Very large initial investment
- ○ Large initial investment
- ○ Moderate initial investment



Revegetation to improve crop pollination

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✓ RELATIVE ADVANTAGE FOR THE POPULATION

✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

✓ Relative upfront cost of the project

15 Reversibility of the innovation

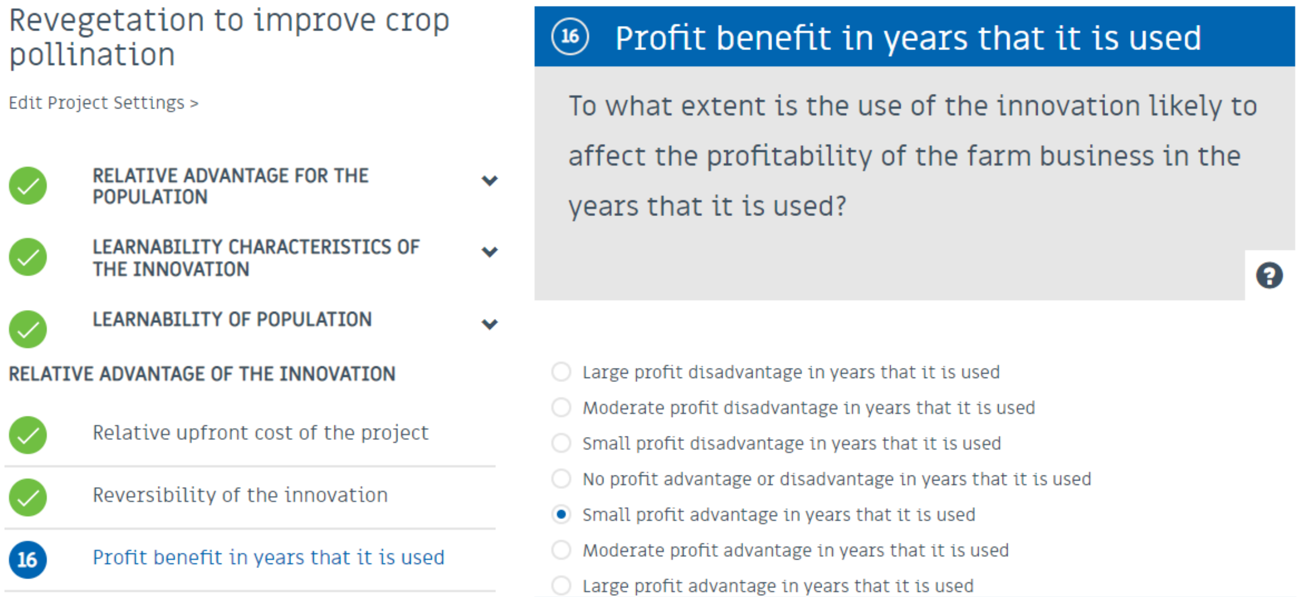
✓ Profit benefit in years that it is used

⑮ Reversibility of the innovation

To what extent is the adoption of the innovation able to be reversed?

○ Not reversible at all
○ Difficult to reverse
● Moderately difficult to reverse
○ Easily reversed
○ Very easily reversed

What is your reasoning for this answer? (Optional)



Revegetation to improve crop pollination

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✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

✓ Relative upfront cost of the project

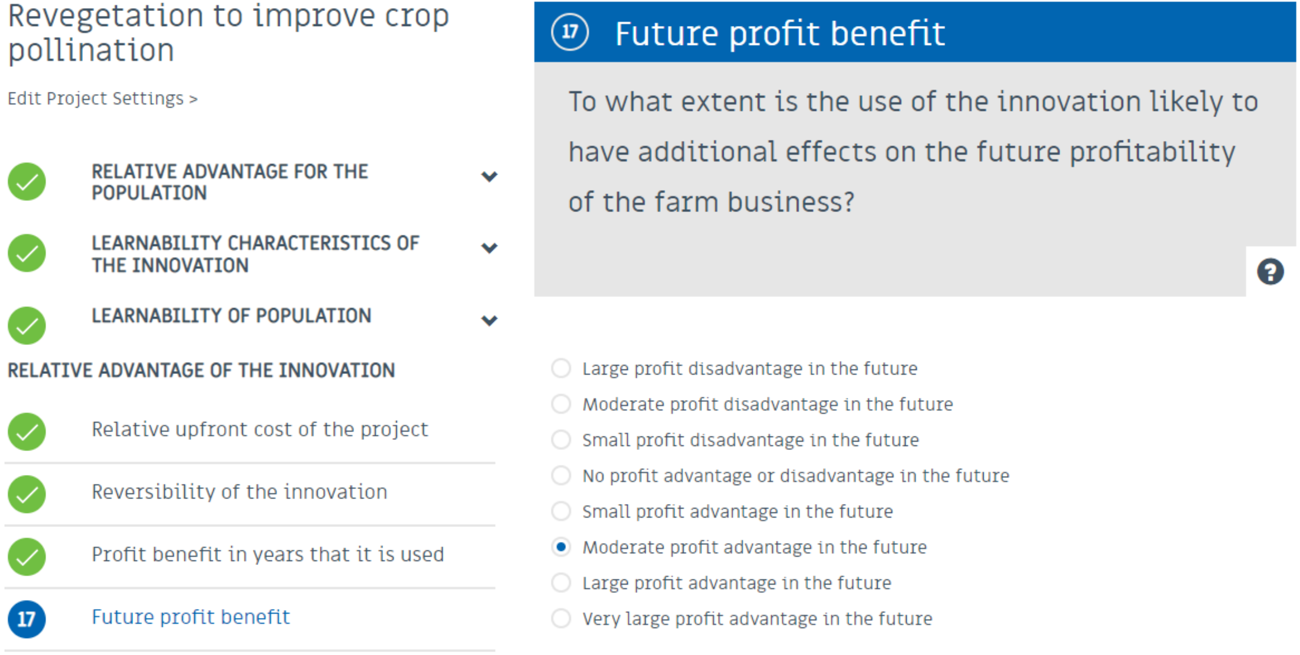
✓ Reversibility of the innovation

16 Profit benefit in years that it is used

⑯ Profit benefit in years that it is used

To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used?

○ Large profit disadvantage in years that it is used
○ Moderate profit disadvantage in years that it is used
○ Small profit disadvantage in years that it is used
○ No profit advantage or disadvantage in years that it is used
● Small profit advantage in years that it is used
○ Moderate profit advantage in years that it is used
○ Large profit advantage in years that it is used



Revegetation to improve crop pollination

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✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

✓ Relative upfront cost of the project

✓ Reversibility of the innovation

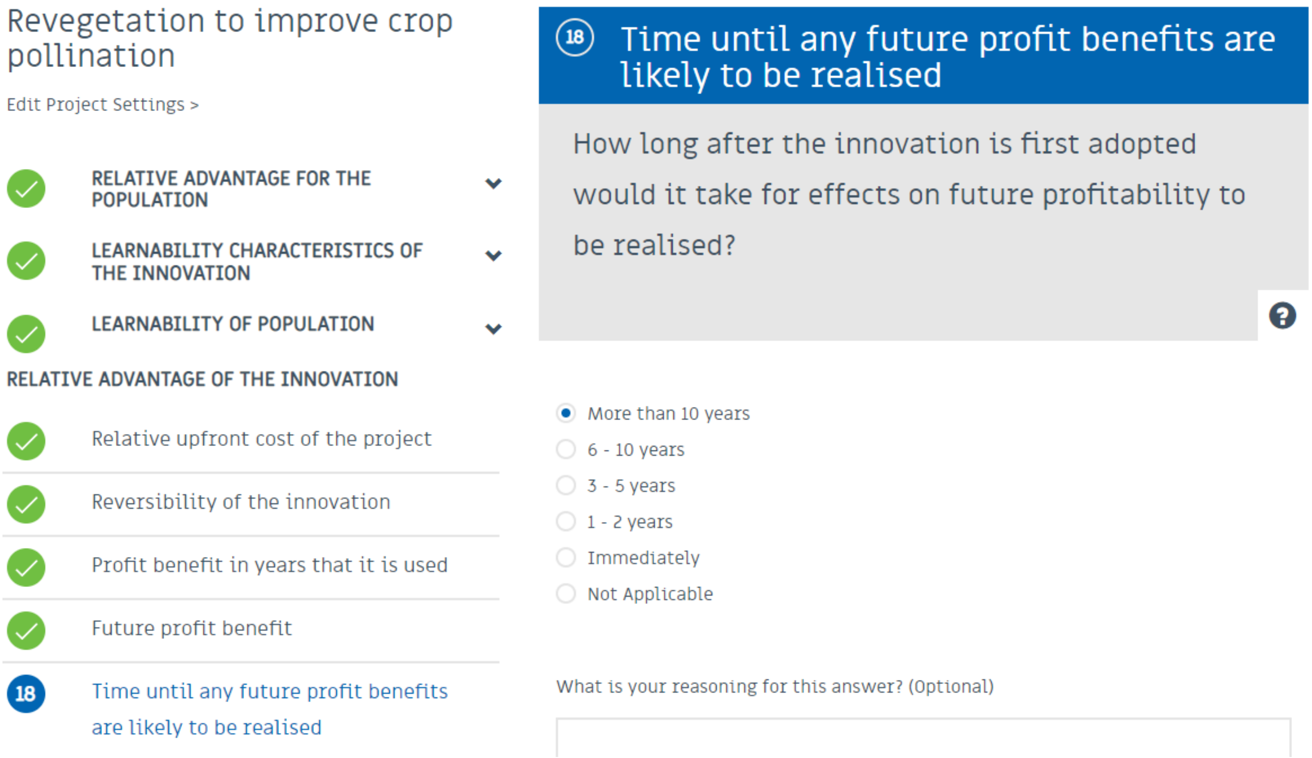
✓ Profit benefit in years that it is used

17 Future profit benefit

⑰ Future profit benefit

To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business?

○ Large profit disadvantage in the future
○ Moderate profit disadvantage in the future
○ Small profit disadvantage in the future
○ No profit advantage or disadvantage in the future
○ Small profit advantage in the future
● Moderate profit advantage in the future
○ Large profit advantage in the future
○ Very large profit advantage in the future



Revegetation to improve crop pollination

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✓ RELATIVE ADVANTAGE FOR THE POPULATION

✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

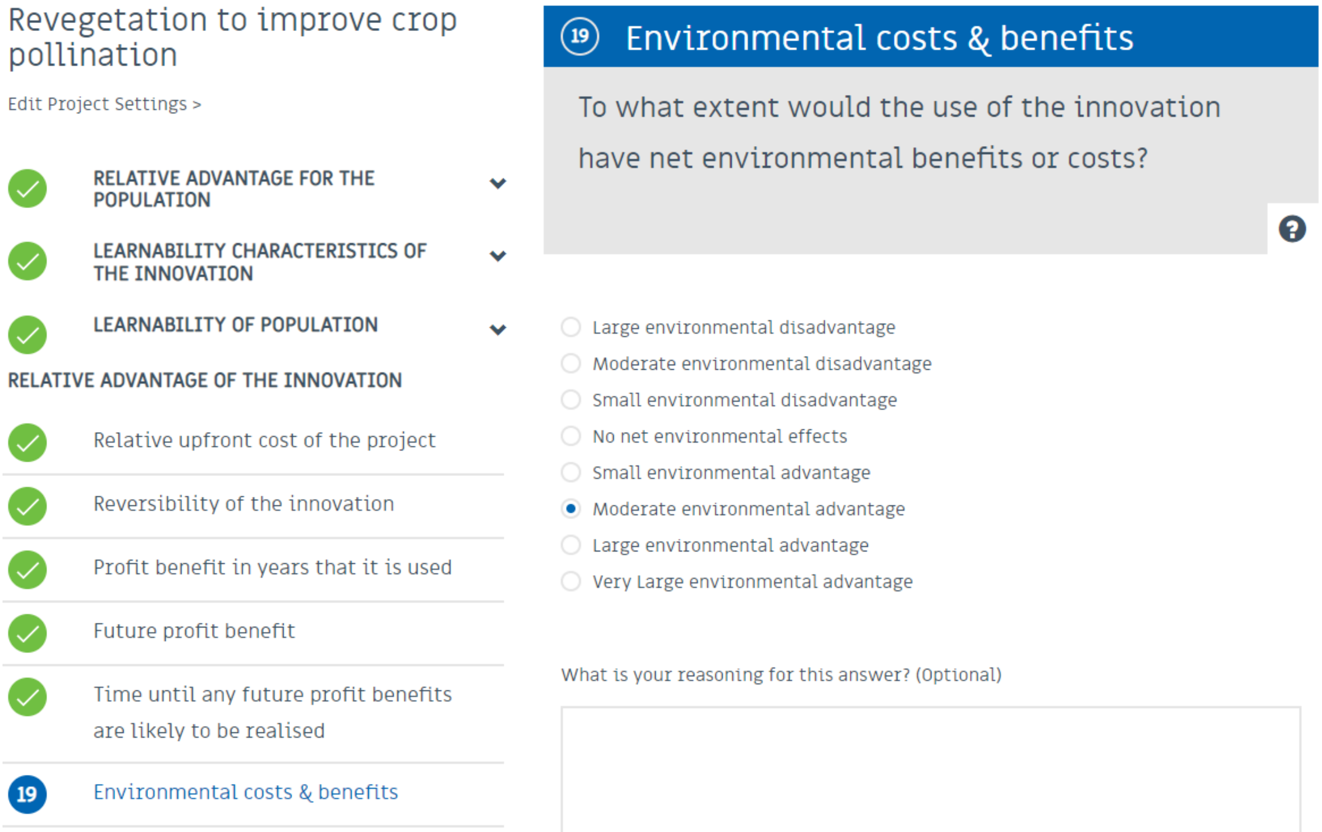
- ✓ Relative upfront cost of the project
- ✓ Reversibility of the innovation
- ✓ Profit benefit in years that it is used
- ✓ Future profit benefit
- 18 Time until any future profit benefits are likely to be realised

18 Time until any future profit benefits are likely to be realised

How long after the innovation is first adopted would it take for effects on future profitability to be realised?

● More than 10 years
○ 6 - 10 years
○ 3 - 5 years
○ 1 - 2 years
○ Immediately
○ Not Applicable

What is your reasoning for this answer? (Optional)



Revegetation to improve crop pollination

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✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

- ✓ Relative upfront cost of the project
- ✓ Reversibility of the innovation
- ✓ Profit benefit in years that it is used
- ✓ Future profit benefit
- ✓ Time until any future profit benefits are likely to be realised
- 19 Environmental costs & benefits

19 Environmental costs & benefits

To what extent would the use of the innovation have net environmental benefits or costs?

○ Large environmental disadvantage
○ Moderate environmental disadvantage
○ Small environmental disadvantage
○ No net environmental effects
○ Small environmental advantage
● Moderate environmental advantage
○ Large environmental advantage
○ Very Large environmental advantage

What is your reasoning for this answer? (Optional)

Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

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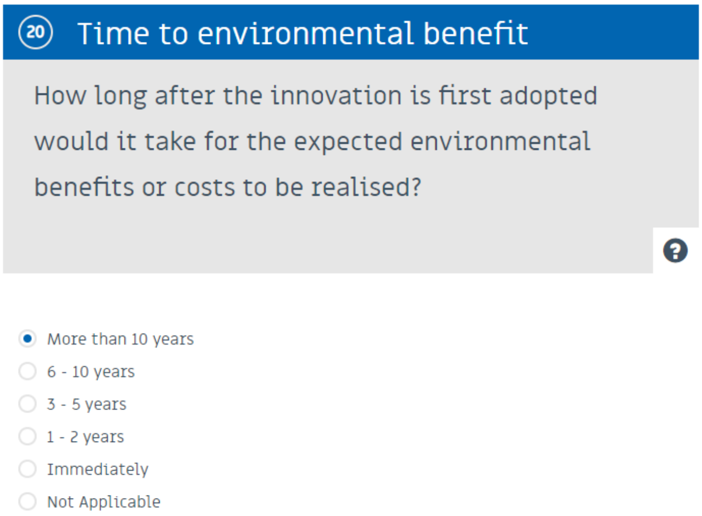
✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

✓ Relative upfront cost of the project

✓ Reversibility of the innovation

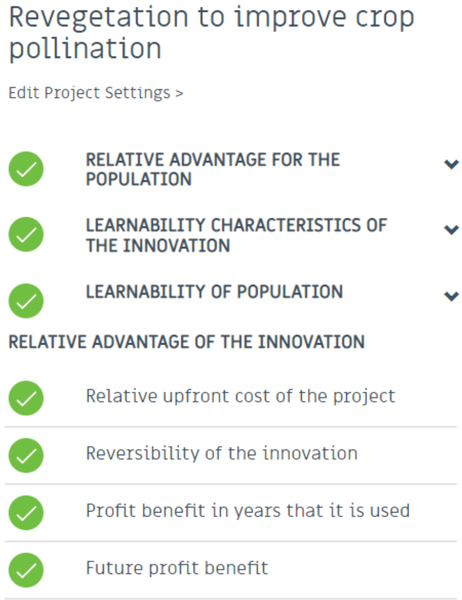
✓ Profit benefit in years that it is used



⑳ Time to environmental benefit

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

● More than 10 years
○ 6 - 10 years
○ 3 - 5 years
○ 1 - 2 years
○ Immediately
○ Not Applicable



Revegetation to improve crop pollination

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✓ LEARNABILITY OF POPULATION

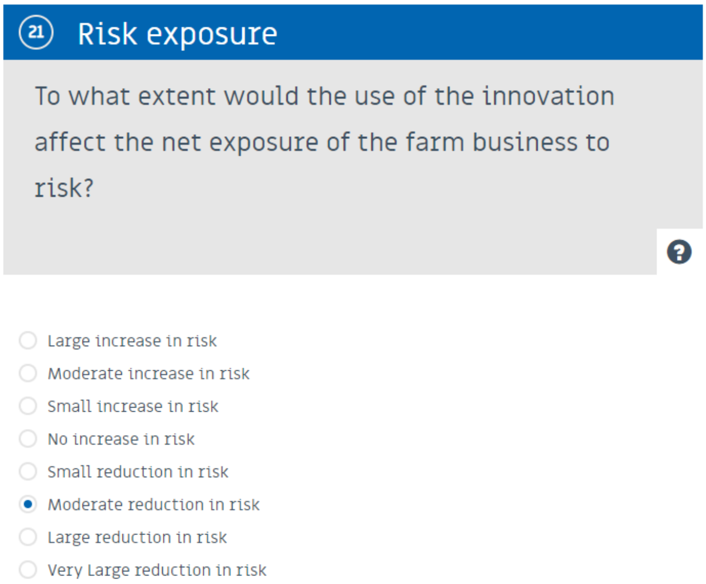
RELATIVE ADVANTAGE OF THE INNOVATION

✓ Relative upfront cost of the project

✓ Reversibility of the innovation

✓ Profit benefit in years that it is used

✓ Future profit benefit



㉑ Risk exposure

To what extent would the use of the innovation affect the net exposure of the farm business to risk?

○ Large increase in risk
○ Moderate increase in risk
○ Small increase in risk
○ No increase in risk
○ Small reduction in risk
● Moderate reduction in risk
○ Large reduction in risk
○ Very Large reduction in risk

Revegetation to improve crop pollination

Edit Project Settings >

✓ RELATIVE ADVANTAGE FOR THE POPULATION

✓ LEARNABILITY CHARACTERISTICS OF THE INNOVATION

✓ LEARNABILITY OF POPULATION

RELATIVE ADVANTAGE OF THE INNOVATION

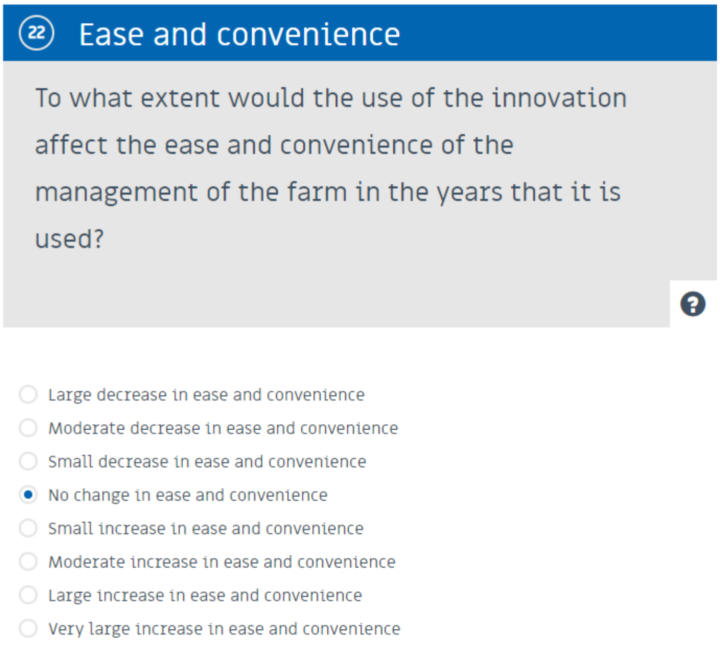
✓ Relative upfront cost of the project

✓ Reversibility of the innovation

✓ Profit benefit in years that it is used

✓ Future profit benefit

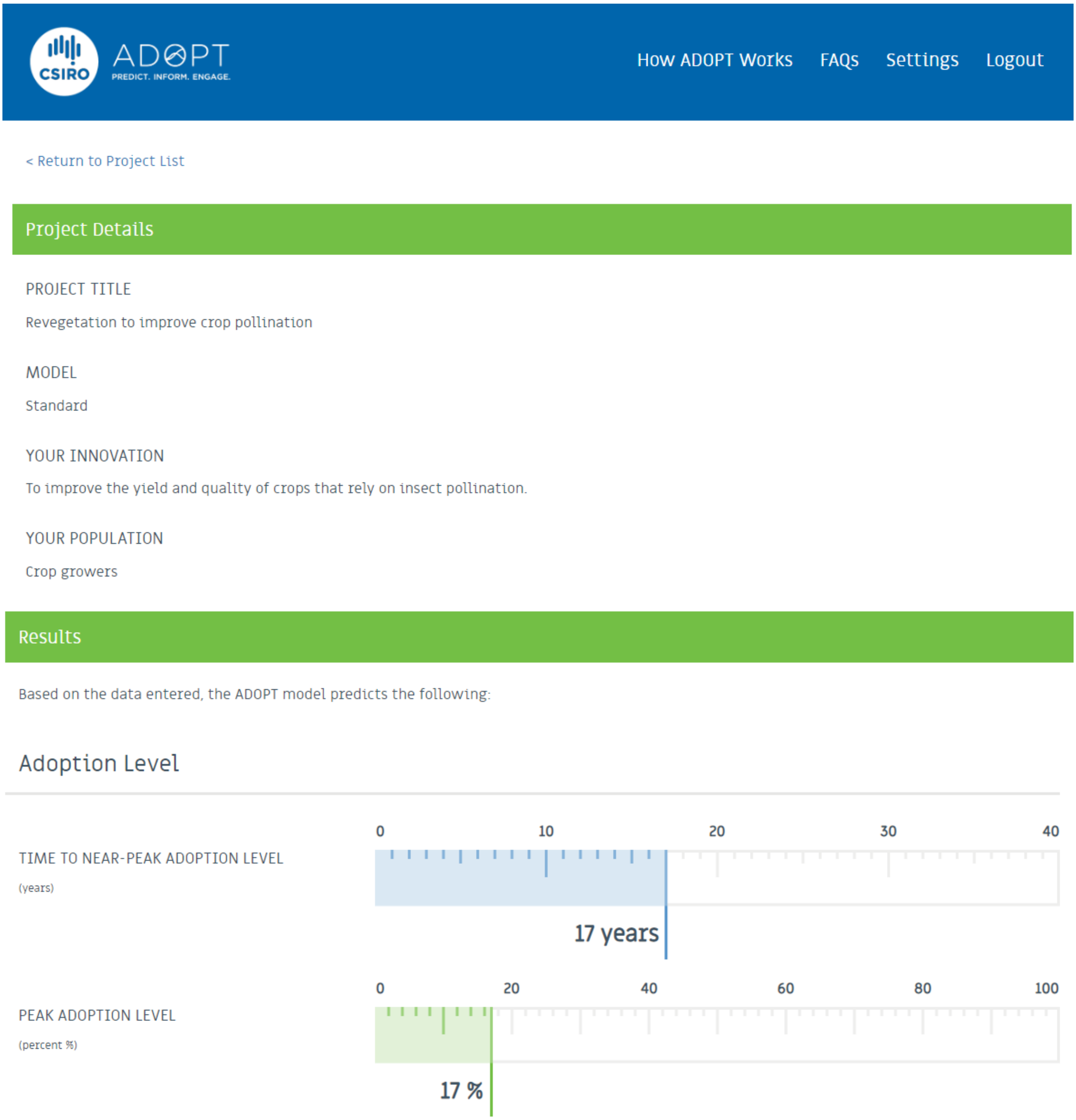
✓ Time until any future profit benefits are likely to be realised



㉒ Ease and convenience

To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used?

○ Large decrease in ease and convenience
○ Moderate decrease in ease and convenience
○ Small decrease in ease and convenience
● No change in ease and convenience
○ Small increase in ease and convenience
○ Moderate increase in ease and convenience
○ Large increase in ease and convenience
○ Very large increase in ease and convenience



Project Details

PROJECT TITLE

Revegetation to improve crop pollination

MODEL

Standard

YOUR INNOVATION

To improve the yield and quality of crops that rely on insect pollination.

YOUR POPULATION

Crop growers

Results

Based on the data entered, the ADOPT model predicts the following:

Adoption Level

TIME TO NEAR-PEAK ADOPTION LEVEL

(years)

17 years

PEAK ADOPTION LEVEL

(percent %)

17 %