Industry-specific impact assessment program: Banana

Impact assessment report for project *Integrated management of yellow sigatoka and other banana diseases in Far North Queensland* (BA12007)

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What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in project BA12007 titled "*Integrated management of Yellow Sigatoka and other banana diseases in Far North Queensland".* The project was funded by Hort Innovation over the period September 2012 to December 2015.

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 BA12007 is likely to have contributed to increased productivity/profitability for some Australian banana growers and reduced regulatory intervention costs for the QLD government. This was achieved through reduced production losses associated with endemic banana diseases and increased compliance with disease control regulations.

Investment Criteria

Total funding from all sources for the project was $0.81 million (present value terms). The investment produced estimated total expected benefits of $3.71 million (present value terms). This produced an estimated net present value of $2.90 million, a benefit-cost ratio of 4.57 to 1 and a modified IRR of 37.7% over 30-years at a discount rate of 5% and a reinvestment rate of 5%.

Conclusions

Some economic and social impacts were identified but not valued as part of the current assessment. Thus, 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 BA12007 investment.

Keywords

Impact assessment, cost-benefit analysis, BA12007, banana, Yellow Sigatoka, integrated disease management, IPDM

Introduction

All research and development (R&D) and marketing levy investments undertaken by Horticulture Innovation Australia Limited (Hort Innovation) are guided and aligned to specific investment outcomes, defined through a Strategic Investment Plan (SIP). The SIP guides investment of the levy to achieve each industry's vision. The current industry SIPs apply for the financial years 2016/17 – 2020/21.

In accordance with the Organisational Evaluation Framework, Hort innovation has the obligation to evaluate the performance of its investment undertaken on behalf of industry.

This impact assessment program addresses this requirement through conducting a series of industry-specific ex-post independent impact assessments of the almond (AL), banana (BA), citrus (CT) and onion (VN) research, development and extension (RD&E) investment funds.

Twenty-nine RD&E investments (projects) were selected through a stratified, random sampling process. The industry samples were as follows:

- Nine AL projects were chosen worth $5.84 million (nominal Hort Innovation investment) from an overall population of 21 projects worth an estimated $10.78 million,
- Eight BA projects worth $3.02 million (nominal Hort Innovation investment) from an overall population of 24 projects worth approximately $16.72 million,
- Eight CT projects worth $5.40 million (nominal Hort Innovation investment) from a total population of 35 projects worth $15.78 million, and
- Four VN projects worth $2.40 million (nominal Hort Innovation investment) from an overall population of 8 projects worth $3.89 million.

The project population for each industry included projects where a final deliverable had been submitted in the five-year period from 1 July 2014 to 30 June 2019. The projects for each industry sample were chosen such that the investments represented (1) at least 10% of the total Hort Innovation RD&E investment expenditure for each industry, and (2) the SIP outcomes (proportionally) for each industry. Four projects had been randomly selected as part of a related Hort Innovation project (MT18011) and were included in the samples for the AL industry (AL14006 and AL16004) and the CT industry (CT15006 and CT15013). This left 25 unique projects randomly selected for evaluation under MT19012.

Project BA12007*: Integrated management of Yellow Sigatoka and other banana diseases in Far North Queensland* was randomly selected as one of the 25 unique MT19012 investments 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 (RDCs), Cooperative Research Centres (CRCs), 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.

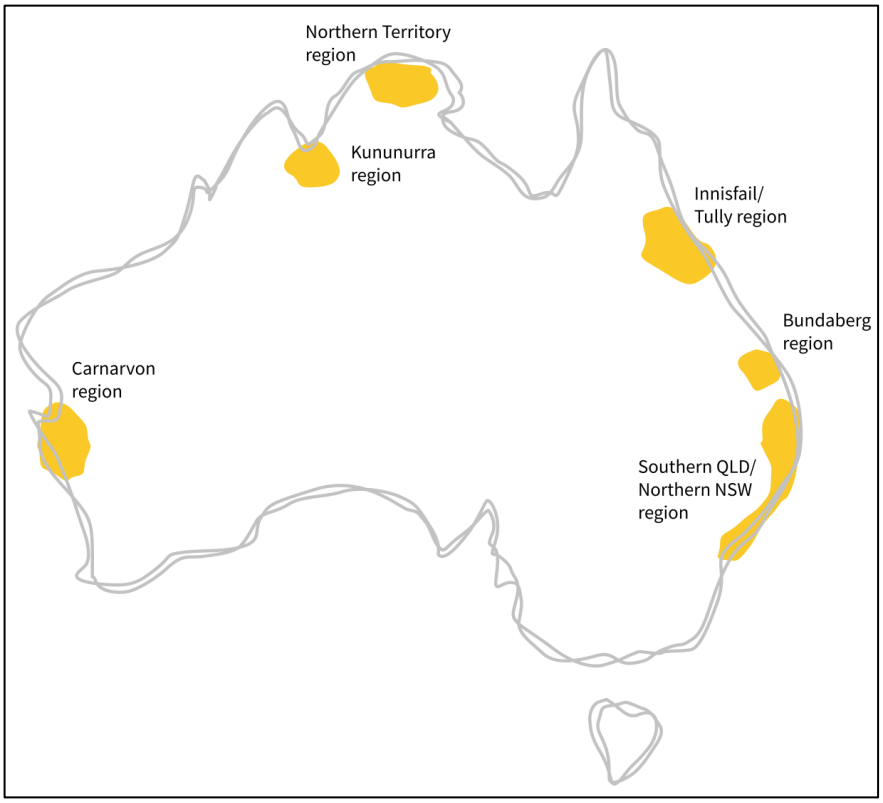
Background & Rationale

Background

The Australian Banana Industry

Bananas have been grown in Australia since the 1880s. Today, bananas are grown in subtropical and tropical regions including in Queensland (Qld), northern New South Wales (NSW), the Northern Territory (NT) and Western Australia (WA) (Hort Innovation, 2020). On average, Qld accounts for approximately 90% of the total area of bananas grown and over 95% of total Australian production (10-year average[1]). Figure 1 shows Australia's banana growing regions and Table 1 provides a summary of the data for production of bananas for both Australia and Qld.

Figure 1: Australia's Banana Growing Regions



Source: https://australianbananas.com.au/Pages/all-about-bananas/the-banana-story

[1] Based on area data from the Australian Bureau of Statistics (ABS), series 7121.0 *Agricultural Commodities, Australia* 2009/10 to 2018/19 and production data from the Australian Banana Growers' Council (ABGC)

Table 1: Production Statistics for the Australian and Qld Banana Industry (year ended 30 June 2010 to 2019)

Australia											
Year ended 30 June	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**10yr Avg.**
Total area (ha)	12,497	13,296	15,484	15,348	12,879	11,788	16,612	14,021	12,477	11,902	13,630
Area (bearing age) (ha)	11,543	11,196	13,496	14,218	12,085	10,936	15,610	13,274	11,551	10,962	12,487
Production[(a)] (t)	309,505	330,980	202,423	339,922	370,176	370,989	395,878	413,660	388,265	371,915	349,371
Yield (t/ha)	26.8	29.6	15.0	23.9	30.6	33.9	25.4	31.2	33.6	33.9	28.0
Gross value ($m)	488.1	316.0	466.8	490.7	341.3	455.0	409.0	538.5	487.6	490.9	448.4
QLD											
Year ended 30 June	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**10yr Avg.**
Total area (ha)	10,869	11,480	13,576	13,886	11,356	10,101	15,794	13,182	11,502	10,829	12,258
Area (bearing age) (ha)	10,083	9,727	11,810	12,986	10,726	9,446	14,933	12,597	10,693	10,030	11,303
Production[(b)] (t)	270,358	287,553	177,135	310,468	328,548	320,442	378,709	392,562	359,425	340,294	316,549
Yield (t/ha)	26.8	29.6	15.0	23.9	30.6	33.9	25.4	31.2	33.6	33.9	28.0
Gross value ($m)	448.3	283.1	415.4	456.5	322.8	440.8	401.2	525.8	472.0	468.3	423.4

Source: ABS Series 7121.0 *Agricultural Commodities, Australia* (2009/10 to 2018/19) and ABS Series 7503.0 *Value of Agricultural Commodities Produced, Australia* (2009/10 to 2018/19)

(a) Production data from the ABGC based on compulsory levies.

(b) Derived from ABS area (bearing age plants) and the Australian average yield for each year.

Yellow Sigatoka and Leaf Speckle

Yellow Sigatoka

Sigatoka leaf spot, commonly known as Yellow Sigatoka, is a fungal disease caused by *Pseudocercospora musicola* (formerly *Mycosphaerella musicola*). The disease reduces the banana plants leaf's photosynthetic capacity, which affects bunch size. Yellow Sigatoka also shortens the banana fruit's green life, reducing the time between harvest and ripening (Biodiversity International, 2020).

Yellow Sigatoka is globally distributed and may cause economic losses, including yield and quality loss, of 20% to 50% (Viljoen, et al., 2017; Balbin & Zapata, 2001; Biodiversity International, 2020). The disease is endemic to all major banana production regions in Australia (except WA) and is actively managed through intensive fungicide treatments and diseased leaf removal (Cook, et al., 2013). Further, Yellow Sigatoka is a prescribed pest that requires plantation owners to keep levels of disease on their plantations below prescribed levels.

Leaf Speckle

Banana Leaf Speckle (also known as banana speckle or tropical speckle) also is an endemic fungal disease caused by three different fungi (*Metulocladosporiella musae, Ramichloridium biverticillatum, and Ramichloridium musae*) (Jackson & McKenzie, 2017). Symptoms of Leaf Speckle are similar to Yellow Sigatoka and include dark blotches and streaks on plant leaves and stalks leading to reduced yield and fruit quality and, potentially, early ripening increasing the risk of infestation by fruit fly.

Rationale

The Hort Innovation Banana Strategic Investment Plan 2017-2021 (2017) identified that continued RD&E investment was needed to improve pest and disease management and biosecurity and to improve the Australian banana industry's integrated pest and disease management (IPDM) plans to reduce the industry's impact on the environment while enhancing crop productivity and profitability.

In 2009, a project to establish a Yellow Sigatoka Liason Officer (YS LO) was funded by industry through Hort Innovation (project BA09055) to conduct regular in-field surveys in north Qld production areas to assess the level of Yellow Sigatoka. The project was due to conclude in July of 2012, however, surveillance activities during the project were severely interrupted by cyclone Yasi with surveillance only occuring for five months during 2012 and for the 12 months from February 2010 to February 2011. Despite this, the YS LO project was widely regarded as successful in terms of monitoring, reporting and addressing lead disease issues on farms in Far North Qld (FNQ). The project worked closely with Biosecurity Qld and achieved significant reductions in regulartory intervention for leaf disease control in the region.

Project BA12007 (*Integrated management of Yellow Sigatoka and other banana diseases in Far North Queensland*) was funded to continue Yellow Sigatoka surveillance and provide banana biosecurity advice to farmers in FNQ. The project focussed on integrated disease management of Yellow Sigatoka and other diseases, both on farms and on host plants that exist in the wider community.

Project Details

Summary

Project Code: BA12007

Title: *Integrated management of Yellow Sigatoka and other banana diseases in Far North Queensland*

Research Organisation: Australian Banana Growers Inc.

Principal Investigator: Jim Pekin

Period of Funding: September 2012 to December 2015

Objectives

Project BA12007 was funded as an extension and expansion of project BA09055. The specific project outcomes required included:

1. The visual surveillance of 100% of farms within the north Qld production area for Yellow Sigatoka and other diseases;
2. A lowering of the risk threat threshold concerning emergency plant pests;
3. A professional working parternship with Biosecurity Queensland (BQ) and the Department of Agriculture and Fisheries (DAF) Qld in north Qld; and
4. The adoption of best practice management on farm for biosecurity issues by at least 60% of growers.

Logical Framework

Table 2 briefly describes the activities, outputs, outcomes, and actual and potential impacts of project BA12007 in a logical framework.

Table 2: Logical Framework for Project BA12007

Activities	• At the commencement of the project (September 2012), a Banana Industry Liaison Officer (known as the YS LO) was engaged to work closely with north Qld commercial banana plantations, BQ and the wider community. • The role was filled by Mr Louis Lardi who was employed through the Australian Banana Growers' Council (ABGC) with Hort Innovation funding. Mr Lardi had effectively conducted this role during the previous project, BA09055. • The YS LO had limited inspectorial powers and conducted regular in-field surveys across the north Qld banana production areas (from Rollingstone to the Daintree, including Mareeba) to assess levels of Yellow Sigatoka and Leaf Speckle. • 256 farms in the area were visited twice yearly from 2012 to 2014, and then at least once in 2015. The intention of the visits was to inspect crops for key diseases and to encouraging more active and voluntary compliance to prescribed disease levels. • During each reporting period, a selection of leaf spot samples was taken to confirm diagnosis of Yellow Sigatoka and a small number were tested for resistance to fungicides. • Testing was conducted by DAF Qld to ensure that the leaf spots were Yellow Sigatoka and not the exotic Black Sigatoka. This activity was important to the exotic disease surveillance program. • In addition to the surveillance activities, the YS LO engaged growers in capacity building to increase awareness and adoption of best management practices (BMPs) for biosecurity. • Mr Lardi educated growers on the symptoms of Yellow Sigatoka and Leaf Speckle, undertook leaf spot inspections, and shared information between growers, aerial operators, chemical sellers, government and university research staff. • The YS LO used a range of extension and communication activities throughout the project, including: one-on-one meetings, organisation and attendance at grower

	meetings, field days, radio interviews, and the dissemination of knowledge through leaflets, posters, and articles published in industry-related magazines, e-bulletins and news. • From March 2015 a major change occurred in the FNQ banana industry with the detection of *Fusarium Wilt Tropical Race 4* (TR4) in Tully. This discovery dramatically changed the way the YS LO undertook his work with many farms in the region going into lockdown in the early stages of the TR4 incursion. • Since the beginning of 2015, the YL SO has helped growers manage TR4 and meet their biosecurity obligations through liaison between growers and BQ on the response to TR4.
Outputs	• Comprehensive disease surveillance data were collected from September 2012 to October 2015 for 98% of farms in the north Qld production area. • A wide range of educational material and activities that promoted on-farm BMPs for disease control were produced/conducted. • 44 leaf spot specimens were collected and analysed by DAF over the duration of the project. • Fungal isolates from a small number of samples (three in total) were tested for resistance to fungicides. Results showed that resistance to strobilurin and triazole fungicides varied from low to high for the three samples taken. • Growers were encouraged to report disease problems. All complaints of excessive disease levels were investigated and acted upon by the YS LO within 24 to 48 hours. • The detection of TR4 in north Qld occurred because the affected grower alerted Mr Lardi to the yellowing leaves of his banana plants. Mr Lardi then inspected the plants and took samples for testing, resulting in the positive diagnosis of TR4 in Tully. • Industry and grower specific information was provided to BQ which assisted the development of the TR4 response. • Advice then was provided to concerned growers and information about the response was provided to industry by Mr Lardi during his participation in daily situation report meetings. • The YS LO also participated in the training of staff working for BQ undertaking TR4 inspections and validated the protocols and maps for BQ and the TR4 extension team.
Outcomes	• The northern banana industry achieved 98% compliance with the relevant disease legislation through a voluntary industry approach between 2012 and 2015. This was substantially higher than the 80% compliance target outlined at the beginning of the project. The high level of compliance may be attributed to the YS LO through successfully: o Conducting visual surveillance twice yearly on 98% of farms in the north Qld production area for early detection and management of Yellow Sigatoka and other such diseases. Only five growers in the whole region refused entry to the YS LO and these were referred to BQ for inspection. o Increasing knowledge and awareness for all growers and local communities of the importance of effective control of endemic pests and diseases. o Achieving greater preparedness for the increased disease pressure associated with the wet season in late spring/summer. This was achieved through one-on-one meetings with growers, the development and distribution of educational material, YS LO attendance at local grower associations, field days, workshops, and media releases. • Improved compliance resulted in a significant reduction in the need for formal regulatory intervention. • Improved surveillance and voluntary compliance also led to reduced overall levels of disease and improved biosecurity against potential incursions of serious exotic pests and diseases such as Black Sigatoka. • The comprehensive database of banana farms now is an important resource for ABGC and BQ to monitor and understand the location, distribution, frequency and spread of disease outbreaks and assess levels of compliance against legislation.

	• The professional partnership between the YS LO, BQ and DAF in north QLD, as well as increased awareness, communication and understanding between government and industry, has facilitated coordination and enhanced biosecurity for the banana industry. • Further, collection and testing of leaf samples contributed to accurate disease diagnosis and potential early detection of disease for the exotic disease surveillance program. • Also, the rapid response of Mr Lardi to the detection of TR4 was of critical importance to the subsequent diagnosis and containment of TR4 in the Tully region. • Two subsequent projects have been funded to continue the work of the YS LO. BA15003 covered the period 2016 to 2018 and a current project, BA17005 (2019 to December 2021). The role of the YS LO has been expanded under BA17005 to include biosecurity extension as well as work on other leaf diseases (Jim Pekin, pers. comm., 2020).
Impacts	• Increased productivity and profitability for banana growers in FNQ. This impact is driven by reduced losses associated with endemic banana diseases through increased compliance with disease control legislation, improved IPDM and enhanced on-farm biosecurity management practices leading to reduced overall levels of disease. • Reduced regulatory intervention costs for government because of improved voluntary compliance associated with disease control for the FNQ banana production area. • Reduced risk of incursion, establishment and/or spread of exotic banana diseases (for example, *Fusarium Wilt TR4*) through enhanced surveillance and detection and improved on-farm biosecurity practices. • Increased industry awareness and understanding of key banana diseases as well as increased industry capacity to prepare for, and respond to, disease outbreaks. • Potentially, increased regional community wellbeing from spillover benefits of a more productive and profitable north Qld banana industry.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project BA12007 by Hort Innovation. Hort Innovation provided 100% of the project's funding.

Table 3: Annual Investment in the Project BA12007 (nominal $)

Year ended 30 June	Hort Innovation ($)	Others ($)	Total ($)
2013	110,540	0	110,540
2014	117,811	0	117,811
2015	117,811	0	117,811
2016	138,170	0	138,170
Totals	484,332	0	484,332

Source: BA12007 Project Agreement and Variation documents supplied by Hort Innovation 2020

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 Annual Report, various years). This multiplier was then applied to the nominal investment by Hort Innovation shown 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, 2020). No additional costs associated with project extension were incorporated as the project included a high level of interaction with industry and government and a number of extension and communication activities were undertaken.

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 BA12007

Economic	• Increased productivity and profitability for banana growers in FNQ. This impact is driven by reduced losses associated with endemic banana diseases through increased compliance with disease control legislation, improved IPDM and enhanced on-farm biosecurity management practices leading to reduced overall levels of disease. • Reduced regulatory intervention costs for government because of improved voluntary compliance associated with disease control for the FNQ banana production area. • Reduced risk of incursion, establishment and/or spread of exotic banana diseases (for example, *Fusarium Wilt TR4*) through enhanced surveillance and detection and improved on-farm biosecurity practices. • Increased industry awareness and understanding of key banana diseases as well as increased industry capacity to prepare for, and respond to, disease outbreaks.
Environmental	• Nil
Social	• Potentially, increased regional community wellbeing from spill-over benefits of a more productive and profitable north Qld banana industry.

Public versus Private Impacts

The impacts identified in this evaluation are both private and public in nature. Private benefits are likely to be realised by north Qld banana growers through reduced production losses through improved management of key endemic banana diseases such as Yellow Sigatoka and Leaf Speckle as well as through a reduced risk of incursion, establishment and/or spread of exotic banana diseases.

Public benefits also may occur and include reduced costs for regulatory intervention because of improved voluntary industry compliance and, potentially, increased regional community wellbeing as a result of a more productive and profitable banana industry.

Distribution of Private Impacts

The impacts on the Australian banana industry from investment in project BA12007 will be shared along the banana supply chains with input suppliers, growers, processors, transporters, wholesalers, retailers and consumers all sharing impacts produced by the project according to relevant short- and long-term supply and demand elasticities.

Impacts on Other Australian Industries

Impacts on industries other than the Australian banana industry are expected to be minimal. However, potential gains to other industries may occur through future spill-overs from the improved surveillance and monitoring of banana diseases relevant to other crop types, as well as improved on-farm biosecurity practices.

Impacts Overseas

No significant or direct impacts for countries outside of Australia were identified. However, the knowledge created by the project and shared through international scientific and industry networks may result in some positive impacts for banana industries overseas where management of Yellow Sigatoka and other similar diseases is ongoing.

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 Priorities 2 and 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: (Commonwealth of Australia, 2015) and (Australian Government, 2015)

Alignment with the Banana Strategic Investment Plan 2017-2021

The strategic outcomes and strategies of the banana industry are outlined in the Banana Strategic Investment Plan 2017-2021[2] (2017). Project BA12007 addressed Outcome 1 (Strategy 1.3 and, to some extent, Strategy 1.4) with some contribution to Outcome 2 (Strategies 3.1 and 3.2).

Valuation of Impacts

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 economic impacts were valued. First was increased productivity/profitability for some banana growers driven by reduced or avoided production losses associated with relevant endemic banana diseases. Second was reduced regulatory intervention costs from improved voluntary compliance associated with banana disease control.

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. In particular, environmental and social impacts were hard to value due to a lack of evidence/data on which to base credible assumptions, difficulty in quantifying the causal relationship and the pathway between BA12007 and the impact and/or the complexity of assigning magnitudes and monetary values to the impact.

The economic impacts identified but not valued were:

- Reduced risk of incursion, establishment and/or spread of exotic banana diseases (for example, *Fusarium Wilt TR4*) through enhanced surveillance and detection and improved on-farm biosecurity practices.
- Increased industry awareness and understanding of key banana diseases as well as increased industry capacity to prepare for, and respond to, disease outbreaks. However, this impact may be partially captured by the valuation of increased productivity/profitability driven by avoided production losses.

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

Though increased industry awareness and understanding of key banana diseases and increased industry capacity was not valued as a separate impact, this would be captured at least in part by the valuation of increased productivity/profitability for some banana growers.

The social impact identified but not valued were:

- Potentially, increased regional community wellbeing from spill-over benefits of a more productive and profitable north Qld banana industry.

Valuation of Impact 1: Increased productivity/profitability for some Australian banana growers

Yellow Sigatoka is established and actively controlled in Australia through intensive chemical treatments and diseased leaf removal. In QLD, the State government imposes standards for de-leafing to minimise the risk of the disease spreading across six defined banana pest quarantine areas.

In around 2018/19, between 15% and 19% of all plantations in northern QLD were affected by leaf spot at any one time (Jim Pekin, pers. comm., 2020). As noted previously (see Background), Yellow Sigatoka may cause economic losses, including yield and quality loss, of 20% to 50% (Viljoen, et al., 2017; Balbin & Zapata, 2001; Biodiversity International, 2020). It was assumed that the investment in BA12007 (between 2012/13 to 2015/16) contributed to increased voluntary compliance with disease control legislation, improved IPDM and enhanced on-farm biosecurity management practices leading to reduced overall levels of disease in north QLD banana plantations.

Specific assumptions for the valuation of Impact 1 are described in Table 6.

Attribution

Despite disease management being regulated for bananas, BA12007 directly contributed to detection and destruction of diseased plant material through the activities of the YS LO. Therefore, for the project period of 2012/13 to 2015/16 it was assumed that 100% of the impact was attributable to investment in BA12007.

Counterfactual

It was assumed that, in the absence of Hort Innovation investment in BA12007 incidence of leaf spot diseases would have been higher due to lower voluntary compliance with disease management regulations and poorer on-farm implementation of biosecurity.

Valuation of Impact 2: Reduced regulatory intervention costs for government in the FNQ banana region

The investment in BA12007 contributed to increased voluntary compliance with regulated disease control processes thereby potentially reducing regulatory intervention costs for government for the FNQ banana production area. The QLD government spent in excess of $322,000 per annum for yellow sigatoka surveillance and enforcement in 2016 (Biosecurity Queensland, 2016).

Specific assumptions for the valuation of Impact 2 are described in Table 6.

Attribution

As for Impact 1, BA12007 directly contributed to improved voluntary compliance with banana disease management. Therefore, 100% of the benefits estimated were assumed to be attributable to investment in BA12007.

Counterfactual

It was assumed that, in the absence of investment in project BA12007, government spending would have been higher over the period 2012/13 to 2015/16.

Summary of Assumptions

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

Table 6: Summary of Assumptions

Variable	Assumption	Source/Comment
Key Baseline Data		
Total average Australian banana production area (bearing age)	12,487 ha	10-year average derived from ABS Series 7121.0 *Agricultural Commodities, Australia* (2009/10 to 2018/19) (see Table 1)
Total average Australian banana production	349,371 t	10-year average, derived from ABGC production statistics based on the compulsory industry levy (see Table 1)
Total average gross value of production	$448.4 million	10-year average derived from ABS Series 7503.0 *Value of Agricultural Commodities Produced, Australia* (2009/10 to 2018/19) (see Table 1)
North QLD production area as a proportion of total Australian area	80%	Based on the Innisfail/Tully production region and the Northern Banana Pest Quarantine Area contributing approximately 80% of banana production (Cook, et al., 2013)
Estimated average net return to growers	$22.00 / 15kg carton	Analyst estimated based on the average net return to grower after marketing and ripening costs reported in the Banana Enterprise Comparison Report 2016/17 (Appendix 1) (Pinnacle Agribusiness, 2018)
Estimated yield loss from leaf spot diseases in affected areas	10%	Conservative estimate, based on reported economic losses of 20% to 50% from Yellow Sigatoka internationally (Viljoen, et al., 2017; Balbin & Zapata, 2001; Biodiversity International, 2020).
Impact 1: Increase productivity/profitability for some Australian banana growers		
Valuation Assumptions		
	WITH BA12007	
Estimated average area affected by leaf spot diseases at any given time	17%	Mid-point of estimate from 15% to 19% (Jim Pekin, pers. comm., 2020)
Estimated average banana yield in regions **not** affected by leaf spot disease	28.0 t/ha	10-year average banana yield (see Table 1)
Estimated average banana yield in regions affected by leaf spot diseases	25.2 t/ha	28.0 t/ha x (1 – 10%)
Total estimated north QLD production (given incidence of leaf spot diseases)	274,954 t	(80% x 12,487 ha x [1 – 17%] x 28.0 t/ha) + (80% x 12,487 x 17% x 25.2 t/ha)
Total estimated net return to growers in north QLD	$403.27 million	274,954 t x 1,000 / 15 kg x $22 / 15kg carton / 1,000,000
First year of impact	2012/13	First year of BA12007

Last year of impact	2015/16	Last year of BA12007 (assumes no further funding)
WITHOUT BA12007		
Estimated average area affected by leaf spot diseases	19%	Analyst estimate - +2% of 'with' scenario
Total estimated north QLD production (given higher prevailing incidence of leaf spot diseases without BA12007)	274,394 t	(80% x 12,487 ha x [1 – 19%] x 28.0 t/ha) + (80% x 12,487 x 19% x 25.2 t/ha)
Total estimated net return to growers in north QLD without BA12007	$402.45 million	274,394 t x 1,000 / 15 kg x $22 / 15kg carton / 1,000,000
Economic loss avoided through reduced incidence of leaf spot diseases from investment in BA12007	$0.8 million p.a. from 2012/13 to 2015/16	$403.27 m - $402.45 m
Risk Factors and Other Variables		
Probability of output	100%	Analyst assumption, based on successful completion of BA12007
Probability of outcome	100%	Analyst assumption, based on evidence of improved voluntary compliance with disease management practices through investment in BA12007
Probability of impact	80%	Analyst assumption, allows for exogenous factors that may affect realisation of impact
Attribution of benefits to investment in BA12007	100%	See 'valuation of impact 1' above
Impact 2: Reduced Qld Government regulatory expenditure		
Valuation Assumptions		
WITH BA12007		
First year of impact	2012/13	First year of BA12007
Last year of impact	2015/16	Last year of BA12007 (assumes no further funding)
Estimated QLD government expenditure on YS surveillance and intervention	$322,000 p.a. from 2012/13 to 2015/16	Based on 2016 government spending of $322,000 (Biosecurity Queensland, 2016)
WITHOUT BA12007		
Increase in government spending required without BA12007	20%	Analyst assumption
Estimated QLD government expenditure on YS without BA12007	$386,400 p.a. from 2012/13 to 2015/16	(1 + 0.2) x $322,000
Total savings due to BA12007	$64,400 p.a.	$386,400 p.a. – $322,000 p.a.
Risk Factors and Other Variables		
Probability of output	100%	Analyst assumption, based on successful completion of BA12007
Probability of outcome	100%	Analyst assumption, based on evidence of improved voluntary compliance with disease

		management practices through investment in BA12007
Probability of impact	80%	Analyst assumption, allows for exogenous factors that may affect realisation of impact
Attribution of benefits to investment in BA12007	100%	See 'valuation of impact 2' above.

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 (2015/16) 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. Hort Innovation funded 100% of the project.

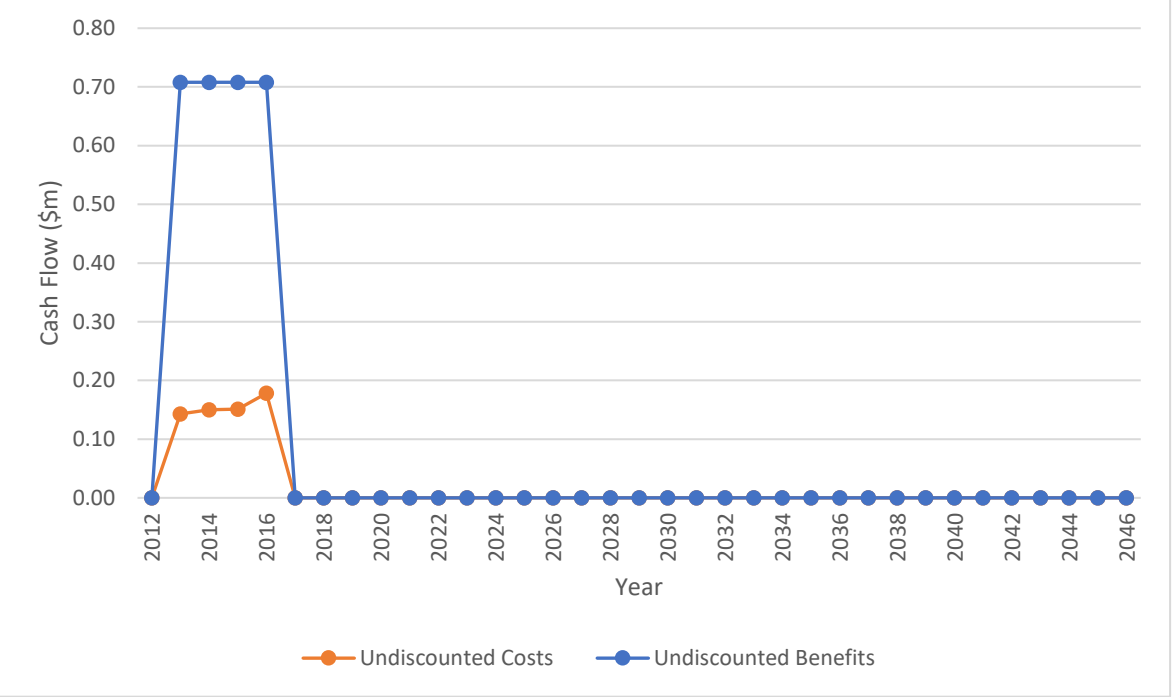
Table 7: Investment Criteria for Total Investment in Project BA12007

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	3.71	3.71	3.71	3.71	3.71	3.71	3.71
Present Value of Costs ($m)	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Net Present Value ($m)	2.90	2.90	2.90	2.90	2.90	2.90	2.90
Benefit-Cost Ratio	4.57	4.57	4.57	4.57	4.57	4.57	4.57
Internal Rate of Return[(a)] (%)	negative	negative	negative	negative	negative	negative	negative
MIRR (%)	negative	304,506.9	295.0	107.0	64.6	45.5	37.7

(a) The internal rate of return is the discount rate at which an investment has a net present value of zero (see Glossary of Economic Terms). In the case of BA12007 the discounted benefit cash flows exceed the discounted costs at year zero (the last year of investment in BA12007), thus there is no positive solution for the internal rate of return.

The annual undiscounted benefit and cost cash flows for the total investment for the duration of BA12007 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



Contribution of Benefits

Table 8 shows the contribution of each impact to the total Present Value of Benefits (PVB).

Table 8: Contribution to Benefits by Source

Impact	PVB ($m)	% of Total PVB
Impact 1: Increased productivity/ profitability	3.44	92.7
Impact 2: Reduced government costs	0.27	7.3
Total	3.71	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 9 present the results. The investment criteria showed a low sensitivity to the discount rate. This was largely because the benefits cash flows occur prior to year zero (the last year of investment in BA12007) and the period of costs and benefits largely coincide (see Figure 2).

Table 9: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5%	10%
Present Value of Benefits ($m)	2.83	3.71	4.81
Present Value of Costs ($m)	0.62	0.81	1.05
Net Present Value ($m)	2.21	2.90	3.76
Benefit-cost ratio	4.55	4.57	4.58

A sensitivity analysis was then undertaken for the proportion of the north QLD banana production area affected by leaf spot diseases without the investment in BA12007 (Impact 1). The results are presented in Table 10 and show a moderate to high sensitivity to the assumed proportion of the area affected by leaf spot without BA12007.

Table 10: Sensitivity to Proportion of north QLD Banana Production Area Affected by Leaf Spot Diseases without BA12007 (Total investment, 30 years)

Investment Criteria	**Proportion of N QLD Area Affected by Leaf Spot without BA12007**		
	18% (+1%)	**19% (+2%) (Base)**	**22% (+5%)**
Present Value of Benefits ($m)	1.99	3.71	8.87
Present Value of Costs ($m)	0.81	0.81	0.81
Net Present Value ($m)	1.18	2.90	8.05
Benefit-cost ratio	2.45	4.57	10.92

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

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

Table 11: Confidence in Analysis of Project

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

Coverage of benefits was assessed as Medium-High – two of the four economic impacts were valued; however, two other impacts were not able to be valued within the scope of the current assessment. Such impacts were considered secondary benefits and were likely small relative to the primary impacts valued.

Confidence in assumptions was rated as Medium. Data used in the analysis were mostly drawn from published and/or credible sources such as Hort Innovation, published scientific works and the ABGC. However, some other assumptions, such as the actual magnitude of impact and the counterfactual, were analyst assumptions and are therefore somewhat uncertain.

Conclusion

The investment in BA12007 is likely to have contributed to increased productivity/profitability for some Australian banana growers and reduced regulatory intervention costs for the QLD government. This was achieved through reduced production losses associated with endemic banana diseases and increased compliance with disease control regulations.

Total funding from all sources for the project was $0.81 million (present value terms). The investment produced estimated total expected benefits of $3.71 million (present value terms). This produced an estimated net present value of $2.90 million, a benefit-cost ratio of 4.57 to 1 and a modified IRR of 37.7% over 30-years at a discount rate of 5% and a refinance rate of 5%.

Three of the five impacts identified were not valued as part of the current quantitative assessment. Thus, given the impacts not valued, combined with conservative assumptions made for the two principal economic impacts valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the BA12007 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.

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Abbreviations

AL	Almond
ABGC	Australian Banana Growers' Council
BA	Banana
BQ	Biosecurity Queensland
CT	Citrus
CRC	Cooperative Research Centre
CRRDC	Council of Rural Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland)
FNQ	Far North Queensland
TR4	Fusarium Wilt Tropical Race 4
Hort Innovation	Horticulture Innovation Australia Ltd
IPDM	Integrated Pest and Disease Management
MIRR	Modified Internal Rate of Return
NSW	New South Wales
NT	Northern Territory
VN	Onion
Qld	Queensland
R&D	Research and Development
RDC	Research and Development Corporation
RD&E	Research, Development and Extension
SIP	Strategic Investment Plan
WA	Western Australia
YS LO	Yellow Sigatoka Liaison Officer