Industry-specific impact assessment program: Banana

Impact assessment report for project *Banana bunchy top virus control data* (BA17001)

Impact analyst:

Talia Hardaker

Delivery partner:

AgEconPlus and Agtrans Research

Project code:

MT19012

Date:

18 December 2020

Funding statement:

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

Publishing details:

Published and distributed by: Hort Innovation

Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

Contents

Tables

Figures

Executive Summary

What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in project BA17001 titled "*Banana Bunchy Top Virus Control Data".* The project was funded by Hort Innovation over the period February 2018 to September 2018.

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 BA17001 has provided tools for assessing banana bunchy top virus (BBTV) management options. The models developed have enabled the assessment of a wide range of surveillance and management scenarios with varying levels of input and professional expertise. The outputs of project BA17001 are likely to have contributed to increased efficiency of future resource allocation to BBTV surveillance and management investments (such as the BBTV management program currently funded by Hort Innovation) and improved management of BBTV in southern QLD and northern NSW leading to a reduced risk of spread of BBTV to northern QLD, southern NSW, WA and the NT.

Investment Criteria

Total funding from all sources for the project was $0.26 million (present value terms). The investment produced estimated total expected benefits of $1.36 million (present value terms). This produced an estimated net present value of $1.11 million, a benefit-cost ratio of 5.26 to 1, an internal rate of return (IRR) of 14.67% and a modified IRR of 9.73% over 30-years at a discount rate of 5% and reinvestment rate of 5%.

Conclusions

A number of economic, environmental, 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 impact valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the BA17001 investment.

Keywords

Impact assessment, cost-benefit analysis, BA17001, banana, banana bunchy top virus, BBTV, control data

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 BA17001*: Banana Bunchy Top Virus Control Data* 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.

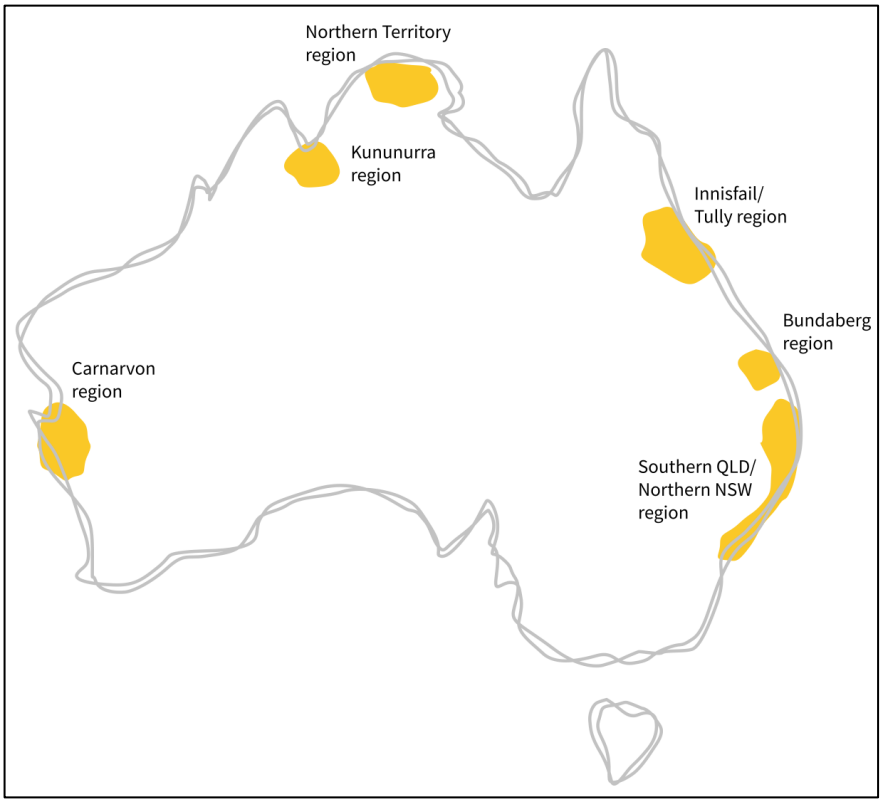
Background & Rationale

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.

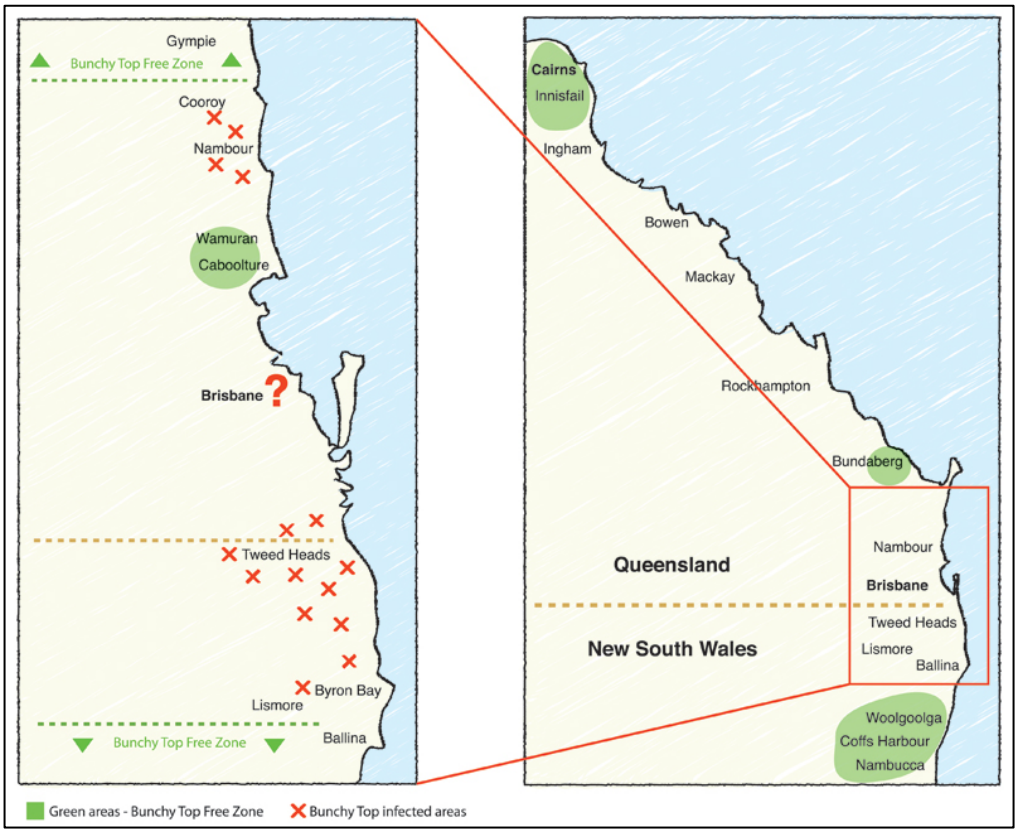
(b) Derived from ABS area (bearing age plants) and the Australian average yield for each year.

Banana Bunchy Top Virus

Bunchy top disease, caused by banana bunchy top virus (BBTV), is one of the most devastating viral diseases of bananas worldwide. The disease is characterised by the 'bunched' appearance of newly emerging leaves and dot-dash flecking of banana plant leaves and petioles (Plant Health Australia, n.d.). BBTV is widespread and exists in Asia, Africa and Oceania. The virus is known to be spread by the banana aphid, *Pentalonia nigronervosa,* and through infected planting material. Plants that are infected when young rarely produce a fruit bunch. When diseased suckers are planted they become severely stunted and do not produce fruit. Plants infected at a later growth stage may produce a distorted bunch (Jackson, 2017).

In Australia, BBTV was first found in the Tweed River area near the border of New South Wales (NSW) and Queensland (QLD) in 1913. Currently, the disease remains restricted to a small area of south-east QLD and northern NSW (Queensland Government, 2019). Figure 2 shows the current distribution of banana bunchy top in Australia. Banana bunchy top inspections are carried out both within the BBTV zone and in commercial plantations in Bundaberg and south of the BBTV zone. A geographic boundary of Cooloola National Park separates Noosa and Gympie, and is an impedance to the aphid-borne northward spread of BBTV (Kathy Crew, pers. comm., 2020).

Figure 2: Distribution of Banana Bunchy Top in Australia



Source: https://www.promusa.org/blogpost263-Australia-s-Hundred-Years-War-on-bunchy-top

The severity of banana bunchy top was illustrated in Australia in the 1920s when approximately 90 per cent of the QLD and NSW banana crops were destroyed. This devastation of the industry prompted State government initiatives to contain BBTV through eradication of infected plants and controls on the movement of planting material from affected areas. This led to a gradual recovery of the banana industry (Cook, et al., 2012).

Rationale

Banana bunchy top virus now is a regulated pest in Australia and containment strategies are in place in both QLD and NSW to prevent the disease from spreading. Cook et al. (2012) estimated that excluding BBTV from commercial banana plantations in Australia would avoid annual losses of between $15.9 and $27.0 million for the banana industry.

From 2009/10 Hort Innovation commenced the first phase (Phase 1) of a ten year program known as the National Banana Bunchy Top Virus Management Project (Project BA08020). The investment represented

a new, science-based strategy (including new surveillance, data recording and extra financial resources) aimed at containing and potentially eradicating BBTV from Australia. Phase 1 ran from 2009/10 to 2011/12, Phase 2 from 2012/13 to 2014/15 (Project BA12006), and Phase 3 from 2015/16 to 2018/19 (Projects BA15006 and BA15007).

Project BA17001: *Banana Bunchy Top Virus Control Data* was funded to complement the work of the Phase 3 BBTV management project by using data collected through Projects BA15006 and BA15007 to develop and parameterise a model for the spatial and temporal spread and control of BBTV in northern NSW and southern QLD.

Project Details

Summary

Project Code: BA17001

Title: *Banana Bunchy Top Virus Control Data*

Research Organisation: The University of Queensland (UQ)

Principal Investigator: John Thomas

Period of Funding: February 2018 to September 2018

Objectives

The desired outcomes of Project BA17001 were to ensure containment and further lower the incidence of banana bunchy top disease, and to provide capacity to ensure faster response time to new incursions of BBTV. The overall aims of the project were to be achieved by:

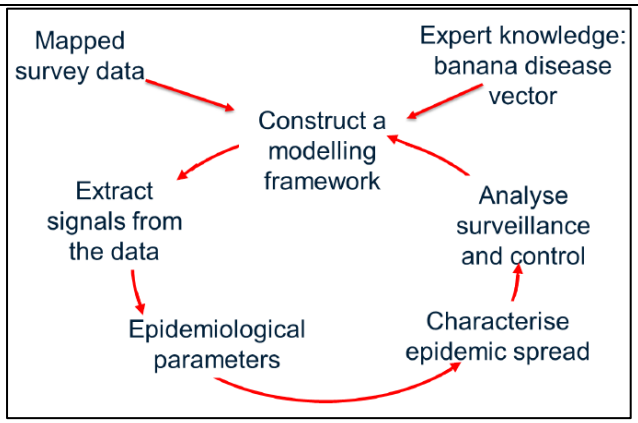
1. Development of a model of BBTV spread.
2. Communication to industry of the implications for preparedness and management of BBTV.
3. Provision of recommendations for future BBTV control programs.

Logical Framework

Table 2 briefly describes the activities, outputs, outcomes, and actual and potential impacts of project BA17001 in a logical framework.

Table 2: Logical Framework for Project BA17001

Activities	• The project worked to develop a modelling framework for the spread of BBTV and to investigate a general approach to informing the choice of control strategies by comparing current practices with some alternative scenarios in a Bayesian framework. • The modelling framework integrated data from surveyed banana bunchy top disease data and expert knowledge to build a quantitative understanding of BBTV dynamics. • This understanding enabled the project team to characterise the epidemic spread of BBTV and support the longer-term goal of building a predictive model of BBTV spread that could be used to predict infection risk and assess the impact of different control strategies. • The image below shows a graphical representation of the project's epidemiological approach:



- Data were supplied, through Hort Innovation projects BA15006 and 15007, on inspections carried out in northern NSW and southern QLD between 2008 and 2017.
- The following information was available in the data: inspection date, infection status of plant, detection and treatment date if symptomatic during the survey, information related to the plant (e.g. number of mats, number of symptomatic leaves and stems) and the location of banana plants surveyed.
- Two modelling components were developed. First, a 'within-plantation spread of infection and disease' model.
- A mechanistic compartmental (SEIS) model was to describe the spread of BBTV within farms considered.
- In the SEIS model, plants were categorized by infection status. Plants that were able to contract the infection were Susceptible (S) until they became Exposed (E) at which point they were infected but not infectious. After a random period of time, plants then became infectious (I). Plants then became susceptible again (S) once detected as infectious, removed and a new sucker replanted.
- Second was a model for spread at larger scale (between plantations and/or across landscapes).
- The broad scale model was based on analysis of disease spread on selected individual plantations.
- A common model was developed across these plantations and took into account seasonal variation, hosts' growth dynamics and other key inherent uncertainties.
- The model could be used to assess control strategies within plantations and to predict spread of infection once the pathogen is introduced into a plantation.
- To look at spread on a wider scale, the approach was followed where the spatio-temporal spread of BBTV was represented stochastically (i.e. allowing for random variation in one or more inputs over time) and in which different mechanisms of spread were combined.
- In particular, the system was represented as an extension of the model described at the plantation level, where the landscape was subdivided into grids.
- To set a baseline, or current practice scenario, a set of standard inspection conditions was identified to define parameters for the modelling.
- Overlaying these standard inspection conditions, the surveillance and management scenario simulations were run on the assumption that either backyards played:
  i) a minor role, or
  ii) a major role in the epidemics.
- The baseline included a number of inspectors (trained to identify BBTV symptoms) undertaking surveillance based on banana farm BBTV categorisation as follows:
  i) Category A – BBTV never recorded
  ii) Category B – No BBTV recorded for 2 years
  iii) Category C – No more than 1 infection in the previous 12 months
  iv) Category D – More than 1 infection in the previous 12 months
  v) Category E – More than 10 infections in the previous 12 months

	• If, during an inspection, an infection was found in a plantation, it was re-inspected in the following month. • This process continued monthly until no new infections are found. At this point inspections continued at 3 monthly intervals for the following year and were then further reduced to 6 monthly intervals the year after, assuming no new infections. If a new infection was found, the surveillance process returns to monthly inspections. • In addition, a sweep of surrounding backyards was carried out within a certain radius (sweep radius) for a sample of infected farms (known as the sweep proportion). • Finally, within a sweep, the proportion of backyards visited and checked (efficiency of the visit and check) was assumed to be approximately 70% overall. • To account for the sensitivity of the detection process it was assumed that inspectors that monitor plantations detect infection at 100% efficiency at later than three-leaf stage. • The baseline scenario was then projected in southern QLD to 2023, using 500 iterations of the epidemic. • The epidemic was initiated at a randomly chosen location from plantations categorized as C, D or E with weight proportional to the size of detection. • Some additional work was undertaken to develop and adapt the computationally rapid contact model for applications in large plantations typical of north QLD and to examine the difficult to control outbreak at Newrybar, NSW.
Outputs	The follow were the key results of the modelling for the southern QLD and northern NSW region: • Continuing with the baseline scenario for surveillance and management was likely to continue to keep the disease in check if backyards play a minor role in the epidemics. • New infections in plantations where detection occurred over the previous year were likely to be picked up before the epidemic 'explodes'. • Scenarios that were less stringent than the baseline have some risk of later epidemic re-occurrence. There is a delay of several years, however, before less stringent scenarios begin to diverge from the baseline but once they do, disease spreads rapidly. • The frequency of visiting plantations had a big effect on disease risk. • Sweeping the surrounding plantations (e.g. sweeping to assess 50% or 100% of plantations out to 1km) had relatively little effect in improving overall disease management. • Reducing the frequency and efficiency of surveillance implied a rapid rise in infections by 2020/21 onwards. • The disease status of plantations where either BBTV has never been recorded or no BBTV is recorded for 2 years and surrounding backyards was very important in driving the epidemic. • Backyards played a role in driving the epidemic but in quite a complicated way. If backyards played a major role, then they can contribute to cryptic build-up of disease and subsequent epidemics. • During the early years, less intensive scenarios sometimes looked good compared with the current practice, but the epidemic was building up and results suggested there could subsequently be a rapid spike in infection.
Outcomes	• The project has provided tools for assessing BBTV management options. The models developed have enabled the assessment of a wide range of surveillance and management scenarios with varying levels of input and professional expertise. • The project outputs have since been used as a resource for planning BBTV management investments by industry. For example, inspection intervals have been reduced to three weeks at times in an attempt to increase detection efficiency and reduce the window when virus spread may occur (John Thomas, pers. comm., 2020).

	• Future work will involve fitting the BBTV models (with environmental covariates such as temperature and precipitation) to data from both southern Qld and northern NSW, to examine the effect of climate change on the transmission of the BBTV. • A new epidemiological research project on BBTV (BA19002) has been funded by Hort Innovation to, in part, investigate/clarify questions arising from the BBTV modelling (Kathy Crew, pers. comm., 2020). • Additional model development has continued through a Bill and Melinda Gates Foundation project, led by John Thomas, to extend the model to banana production in sub-Saharan Africa (Kathy Crew, pers. comm., 2020). • In this work, spread under tropical conditions is being evaluated with the aim of modifying the model for areas such as north QLD (John Thomas, pers. comm., 2020).
Impacts	• Increased efficiency of resource allocation to BBTV surveillance and management investments such as the BBTV management program currently funded by Hort Innovation. • Potentially, some contribution to maintained or increased productivity/ profitability for Australian banana producers through the project's contribution to improved management of BBTV in southern QLD and northern NSW and therefore a reduced risk of spread of BBTV to northern QLD, southern NSW, WA and the NT. • Increased scientific knowledge and research capacity through developments in BBTV epidemiological modelling. • Potentially, some contribution to maintained or enhanced regional community wellbeing in the future through spillover benefits from maintained/increased banana producer incomes.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project BA17001 by Hort Innovation. Other project contributors included UQ and the University of Cambridge.

Table 3: Annual Investment in the Project BA17001 (nominal $)

Year ended 30 June	Hort Innovation ($)	Others ($)	Total ($)
2018	89,533	39,035	128,568
2019	22,383	9,759	32,142
Totals	111,916	48,794	160,710

Source: derived from BA17001 Project Agreement and Variation documents supplied by Hort Innovation 2020

Program Management Costs

For the Hort Innovation investment the cost of managing and administering 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.

It was noted that the University of Cambridge made in-kind contributions over the life of the project that were significantly greater than the budget estimates in the original project documentation (John Thomas, pers. comm., 2020). Thus, for the investment by Others, a cost multiplier of 2.0x was applied to the figures 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 industry interaction and included a number of extension and communication activities.

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 BA17001

Economic	• Increased efficiency of resource allocation to BBTV surveillance and management investments such as the BBTV management program currently funded by Hort Innovation. • Potentially, some contribution to maintained or increased productivity/ profitability for Australian banana producers through the project's contribution to improved management of BBTV in southern QLD and northern NSW and therefore a reduced risk of spread of BBTV to northern QLD, southern NSW, WA and the NT.
Environmental	• Nil.
Social	• Increased scientific knowledge and research capacity through developments in BBTV epidemiological modelling. • Potentially, some contribution to maintained or enhanced regional community wellbeing in the future through spillover benefits from maintained/increased banana producer incomes.

Public versus Private Impacts

The impacts identified in this evaluation are likely to be both predominantly private. Private benefits are likely to be realised by banana producers where the models contribute to improvement management and containment of BBTV. Also, industry may benefit at a broader scale from increased efficiency of private resource allocation to BBTV surveillance and management activities, where such exist.

Some public benefits also may occur and include increased efficiency of public resource allocation for BBTV RD&E (including surveillance and management programs funded through Hort Innovation), as well as increased scientific capacity and, potentially, enhanced regional community wellbeing.

Distribution of Private Impacts

The impacts on the Australian banana industry from investment in project BA17001 will primarily be captured by banana growers in QLD and NSW.

Impacts on Other Australian Industries

No direct or significant impacts to other Australian industries were identified. However, it is possible that other industries may benefit from knowledge shared about new and improved disease modelling (as a generic applied technique) from the project.

Impacts Overseas

No direct impacts to overseas parties were identified. However, information sharing through international scientific networks may result in some positive impacts for overseas parties also managing BBTV.

Match with National Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 5. The project findings and related impacts will contribute to Rural RD&E Priority 1 and 2, 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 the Banana Strategic Investment Plan 2017-2021[2] (2017). Project BA17001 primarily addressed Outcome 1 through Stategy 1.3 with some contribution to Outcome 2 through Strategy 2.1.

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.

One principal economic impact was valued. This was the project's contribution to increased or maintained productivity/profitability through improved management of BBTV and the reduced risk of the spread of BBTV to northern QLD, southern NSW, WA and the NT (that is, the continued exclusion of BBTV from the majority of Australian commercial banana plantations).

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. In particular, 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 BA17001 and the impact and/or the complexity of assigning magnitudes and monetary values to the impact.

The economic impact identified but not valued was:

- Increased efficiency of resource allocation to BBTV surveillance and management investments such as the BBTV management program currently funded by Hort Innovation.

The social impacts identified but not valued were:

- Increased scientific knowledge and research capacity through developments in BBTV epidemiological modelling.
- Potentially, some contribution to maintained or enhanced regional community wellbeing in the future through spillover benefits from maintained/increased banana producer incomes.

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

Valuation of Impact 1: Increased or maintained productivity/profitability through reduced risk of the spread of BBTV

Using a stratified diffusion spread model to simulate the likely benefits of exclusion of BBTV from commercial banana plantations over time relative to a nil management scenario in which no surveillance or containment activities took place, Cook et al. (2012) estimated that excluding BBTV from commercial banana plantations in Australia would avoid annual losses of between $15.9 and $27.0 million for the banana industry.

Outputs from the investment in BA17001 are likely to have resulted in improved planning of BBTV management investments by industry and government. For example, changes to inspection intervals to increase detection efficiency and reduce the window when virus spread may occur (John Thomas, pers. comm., 2020). It was assumed that BA17001 has contributed to the continued exclusion of BBTV from major Australian banana plantations by improving BBTV management and reducing the risk of spread of BBTV.

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

Attribution

A number of investments both past and current contribute to ongoing management and containment of BBTV in Australia and ongoing RD&E investment continues to deliver outputs intended to improve control of BBTV and minimise or eradicate banana bunchy top disease. Project BA17001 is likely to have made planning BBTV containment and management strategies more efficient but is unlikely to have an impact without other investments for surveillance and testing, on ground management and regulatory intervention, and extension. Thus, to acknowledge the contributions of such other BBTV RD&E investment, an attribution factor of 5% was applied to the estimated benefits.

Counterfactual

Successful delivery of project BA17001 relied on a high level of cooperation between industry (through contributions to BBTV data), Australian researchers and researchers at the University of Cambridge. It was assumed that, without the investment in BA17001, the benefits estimated would not have occurred.

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
Impacts 1: Reduced risk of spread of BBTV		
WITHOUT investment		
Avoided total annual losses for the Australian banana industry through exclusion of BBTV from commercial banana plantations	$15.9 million	Cook et al. (2012)
Estimated value of annual losses avoided through exclusion of BBTV from commercial banana plantations given BBTV has not been eradicated in southern QLD and northern NSW and that there would likely be some effort/ investment by industry and/or government in BBTV control in the future should BBTV spread.	$8.0 million	Conservative analyst estimated based on a lower estimated of $15.9 million p.a. against a case of nil BBTV management in Cook et al. (2012).
Time for a BBTV incursion to reach maximum spread and impact	15 years (i.e. avoided annual losses increase to a maximum of $8 million p.a. over 15 years)	Based on the period between the first detection of BBTV in Australia in 1913 and identification of BBTV and implementation of BBTV

		management strategies in 1927 (Vezina, 2013)
Risk of a further BBTV incursion and subsequent spread to other regions	15% each year	Analyst assumption
WITH investment		
Reduction in the risk of further incursion and spread of BBTV	5% (that is, the risk is reduced to 10% each year)	Analyst assumption after consultation with John Thomas (project leader)
First year of impact	2019/20	Year after completion of project BA17001
Risk Factors and Other Variables		
Probability of output	100%	Analyst assumption, based on successful completion of BA17001
Probability of outcome	80%	Analyst assumption – refers to the probability that the BBTV model will be used to improve ongoing management and containment of BBTV
Probability of impact	80%	Analyst assumption, allows for exogenous factors that may affect realisation of impact
Attribution of benefits to investment in BA17001	5%	See 'valuation of impact 1' 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 (2018/19) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Table 7 shows the investment criteria estimated for different periods of benefit for the total investment. Table 8 shows the investment criteria estimated for different periods for the Hort Innovation only. The present value of benefits (PVB) for Hort Innovation was estimated by multiplying the total PVB by the proportion of Hort Innovation investment in project BA17001 (57.1%).

Table 7: Investment Criteria for Total Investment in Project BA17001

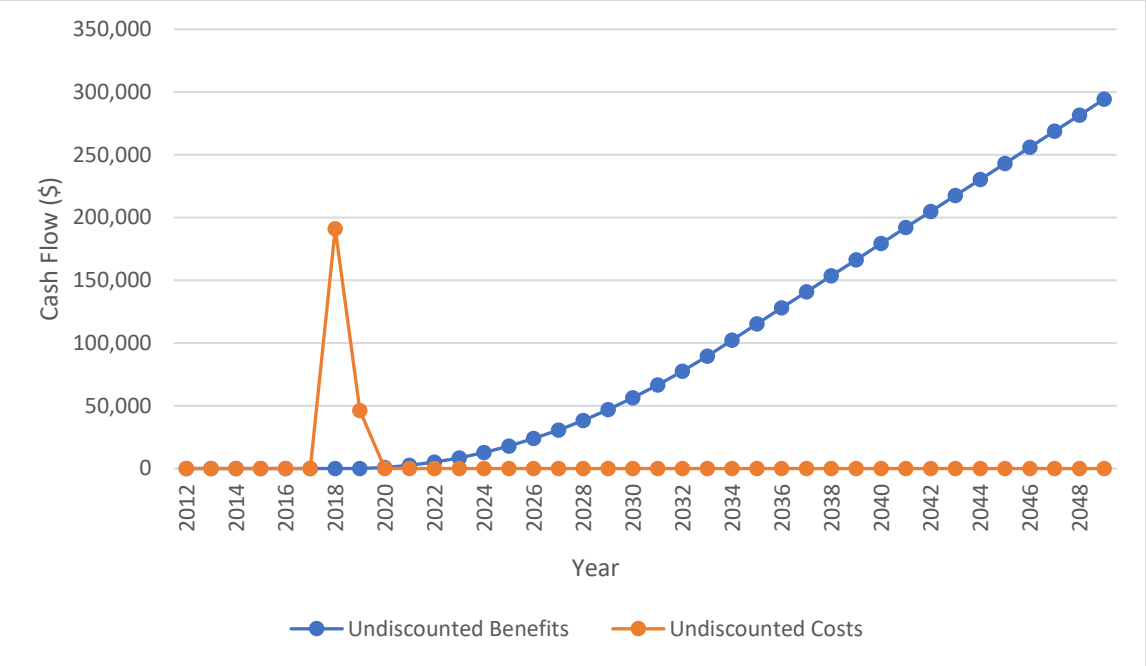
Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.00	0.03	0.14	0.35	0.66	1.01	1.36
Present Value of Costs ($m)	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Net Present Value ($m)	-0.26	-0.23	-0.12	0.09	0.40	0.75	1.11
Benefit-Cost Ratio	0.00	0.10	0.52	1.36	2.53	3.88	5.26
Internal Rate of Return (%)	negative	negative	negative	7.77	11.96	13.80	14.67
MIRR (%)	negative	negative	negative	6.29	9.06	9.76	9.73

Table 8: Investment Criteria for Hort Innovation Investment in Project BA17001

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Benefits ($m)	0.00	0.01	0.08	0.20	0.38	0.57	0.78
Present Value of Costs ($m)	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Net Present Value ($m)	-0.15	-0.13	-0.07	0.05	0.23	0.43	0.63
Benefit-Cost Ratio	0.00	0.10	0.52	1.36	2.53	3.88	5.26
Internal Rate of Return (%)	negative	negative	negative	7.77	11.96	13.80	14.65
MIRR (%)	negative	negative	negative	6.29	9.06	9.76	9.73

The annual undiscounted benefit and cost cash flows for the total investment for the duration of BA17001 investment plus 30 years from the last year of investment are shown in Figure 3.

Figure 3: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs



Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 9 present the results. The results were moderately sensitive to the discount rate. This was largely because the benefit cash flows, in particular, occur into the long-term future and future cash flows are subjected to more significant discounting relative to the investment.

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

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present Value of Benefits ($m)	3.65	1.36	0.59
Present Value of Costs ($m)	0.24	0.26	0.28
Net Present Value ($m)	3.41	1.11	0.31
Benefit-cost ratio	15.38	5.26	2.09

A sensitivity analysis was then undertaken for the reduction in the risk of further incursion and spread of BBTV attributable to BA17001 assumed for Impact 1. The results are presented in Table 10 and show a moderate to high sensitivity to the assumed reduction risk. This was expected as the reduction is risk is the primary driver of the economic model. A break-even analysis indicated that, with all other assumptions held at their base values, the investment criteria remain positive (a benefit-cost ratio of 1:1) at an assumed risk reduction of 1.0%.

Table 10: Sensitivity to Assumed Reduction in Risk of Further BBTV Incursion and Spread (Total investment, 30 years)

Investment Criteria	**Reduction in risk of BBTV incursion and spread**		
	0.5%	**5.0% (base)**	**10.0%**
Present Value of Benefits ($m)	0.14	1.36	2.73
Present Value of Costs ($m)	0.26	0.26	0.26
Net Present Value ($m)	-0.12	1.11	2.47
Benefit-cost ratio	0.53	5.26	10.52

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 – the economic impact that was valued was considered the primary and most important impact of the investment; however, three potential economic, environmental and social impacts were not able to be valued within the current assessment. These impacts, however, were considered secondary potential benefits and were likely small relative to the primary impact valued.

Confidence in assumptions was rated as Medium. Data used in the analysis were drawn from published and/or credible sources such as Hort Innovation, published scientific journal articles and expert scientific opinion. However, a number of other key assumptions were analyst assumptions and were therefore somewhat uncertain.

Conclusion

The investment in BA17001 has provided tools for assessing BBTV management options. The models developed have enabled the assessment of a wide range of surveillance and management scenarios with varying levels of input and professional expertise. The outputs of project BA17001 are likely to have contributed to increased efficiency of future resource allocation to BBTV surveillance and management investments (such as the BBTV management program currently funded by Hort Innovation) and improved management of BBTV in southern QLD and northern NSW leading to a reduced risk of spread of BBTV to northern QLD, southern NSW, WA and the NT.

Total funding from all sources for the project was $0.26 million (present value terms). The investment produced estimated total expected benefits of $1.36 million (present value terms). This produced an estimated net present value of $1.11 million, a benefit-cost ratio of 5.26 to 1, an internal rate of return (IRR) of 14.67% and a modified IRR of 9.73% over 30-years at a discount rate of 5% and reinvestment rate of 5%

A number of economic, environmental and social impacts were also 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 impact valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the BA17001 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.

Reference List

Australian Bureau of Statistics. (2020, March 4). *5206.0 - Australian National Accounts: National Income, Expenditure and Product, Dec 2019*. Retrieved June 2020, from Australian Bureau of Statistics: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5206.0Dec%202019?OpenDocument

Australian Bureau of Statistics. (various (2011-2020)). *7121.0 Agricultural Commodities, Australia*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release

Australian Bureau of Statistics. (various (2011-2020)). *7503.0 Value of Agricultural Commodities Produced, Australia*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/industry/agriculture/value-agricultural-commodities-produced-australia/latest-release

Australian Government. (2015). *Science and Research Priorities.* Canberra: Department of Industry, Innovation and Science. Retrieved from https://www.industry.gov.au/sites/g/files/net3906/f/2018-10/science_and_research_priorities_2015.pdf

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

Cook, D. C., Liu, S., Edwards, J., Villalta, O. N., Aurambout, J.-P., Kriticos, D. J., . . . De Barro, P. J. (2012, August). Predicting the Benefits of Banana Bunchy Top Virus Exclusion from Commercial Plantations in Australia. *PLoS ONE, 7*(8). Retrieved September 2020, from https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0042391&type=printable

Council of Rural Research and Development Corporations. (2018). *Cross-RDC Impact Assessment Program: Guidelines.* Canberra ACT: Council of Rural Research and Development Corporations. Retrieved October 2020, from https://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Horticulture Innovation Australia Ltd. (2017). *Banana Strategic Investment Plan.* Sydney, NSW: Horticulture Innovation Australia Ltd.

Horticulture Innovation Australia Ltd. (2020). *The Banana Story*. Retrieved September 2020, from Australian Bananas: https://australianbananas.com.au/Pages/all-about-bananas/the-banana-story

Horticulture Innovation Australia Ltd. (various (2017-2020)). *Annual Report.* Sydney NSW: Horticulture Innovation Australia Ltd. Retrieved June 2020, from https://www.horticulture.com.au/hort-innovation/funding-consultation-and-investing/investment-documents/company-annual-report/

Jackson, G. (2017). *Banana bunchy top (121)*. Retrieved September 2020, from Pacific Pests and Pathogens - Fact Sheets: https://www.pestnet.org/fact_sheets/banana_bunchy_top_121.htm

Plant Health Australia. (n.d.). *Banana bunchy top disease.* Retrieved from Plant Health Australia: https://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Banana-bunchy-top-disease-FS.pdf

Queensland Government. (2019, July 31). *Priority plant pests and diseases - Banana bunchy top*. Retrieved from Queensland Government Business Queensland: https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/priority-pest-disease/banana-bunchy-top#:~:text=Banana%20bunchy%20top%20is%20caused,affect%20human%20or%20animal%20health.

Vezina, A. (2013, April 10). *Australia's Hundred Years War on bunchy top*. Retrieved October 2020, from ProMusa: https://www.promusa.org/blogpost263-Australia-s-Hundred-Years-War-on-bunchy-top

Acknowledgements

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

Specific acknowledgments:
Kathy Crew, Senior Plant Pathologist (Virology), Agri-Science Queensland, Department of Agriculture and Fisheries Queensland
John Thomas, Associate Professor and Principal Research Fellow, Centre for Horticulture Science, Queensland Alliance for Agriculture and Food Innovation
Brendan O'Keeffe, Analyst, Horticulture Innovation Australia Ltd

Abbreviations

ABGC	Australian Banana Growers' Council
ABS	Australian Bureau of Statistics
AL	Almond
BA	Banana
BBTV	Banana Bunchy Top Virus
CRC	Cooperative Research Centre
CRRDC	Council of Rural Research and Development Corporations
CT	Citrus
Hort Innovation	Horticulture Innovation Australia Ltd
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NSW	New South Wales
NT	Northern Territory
PVB	Present Value of Benefits
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
SEIS	Susceptible, Exposed, Infectious, Susceptible
SIP	Strategic Investment Plan
UQ	University of Queensland
VN	Onion
WA	Western Australia