Impact assessment of the investment:

Banana bunchy top virus project (Phase 4) – National surveillance and education (BA18000)

*By George Revell, **Ag Econ***
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Hort Innovation

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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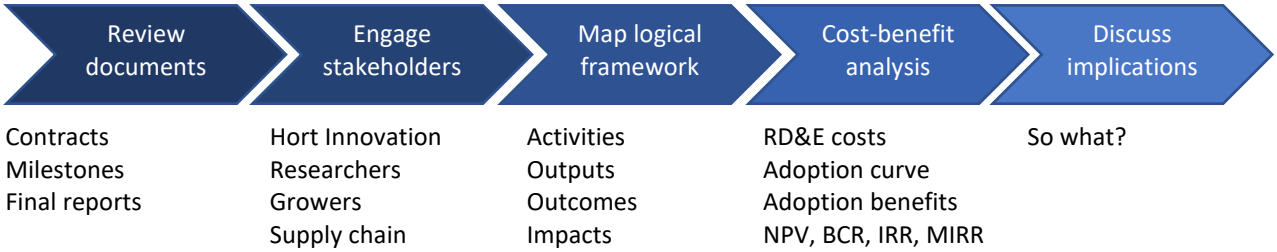
What the report is about

Ag Econ conducted independent analysis determine the economic, social, and environmental impact resulting from delivery of the banana project *Banana bunchy top virus project (Phase 4) – National surveillance and education (BA18000)*. The project was funded by Hort Innovation over the period July 2019 to July 2022 using the banana research and development levy and contributions from the Australian Government. The project was delivered by the Australian Banana Growers' Council (ABGC).

The analysis applied a five step analytical process to understand the impact pathway and collect supporting data.



Research background

From 2019-20 to 2022-23, Horticulture Innovation engaged ABGC to continue the National surveillance and education program for BBTV. Through phases 1-3 the program had successfully contained BBTV in two control zones in Queensland and New South Wales, thereby protecting 95% of national banana production from the virus. BA18000 was contracted to continue the program into phase 4, with a focus on ongoing containment and if possible a reduction of BBTV prevalence, as well as an increased focus on grower responsibility and ownership for BBTV surveillance and control.

Key findings

The nominal investment cost of $2.13 million was adjusted for inflation (ABS, 2024) and discounted (using a 5% real discount rate) to a 2023-24 present value (PV) of costs equal to $2.80 million.

The analysis conducted a detailed evaluation of the BA18000 impact pathway through a logical framework, a review of the available data, and discussions with key program stakeholders. From this process a clear impact pathway was identified between the delivery of BA18000 and the reduced industry risk associated with BBTV. Furthermore, sufficient data was identified to quantify the impact.

A model was developed to compare a with-BA18000 and without-BA18000 scenario which showed that the project supported an industry benefit (avoided industry losses) of $47.34 million between 2019-20 and 2052-53.

Compared to the RD&E cost, these benefits generated a net present value (NPV) of $44.54 million, and a benefit cost ratio (BCR) of 16.90:1.

Sensitivity testing showed a very wide potential impact range of between 2.70:1 and 38.47:1, with 90% of results falling between 6.45:1 and 27.07:1 giving a high level of confidence that the investment generated a positive impact. The variation was driven primarily by banana price, as well as the potential speed and area of spread of BBTV without containment. There was generally a high level of data available for the analysis; however, the model still displayed a wide variation in results reflecting the complexity of estimating BBTV spread and the uncertainty over the banana price outlook.

The analysis re-enforces the earlier estimates of the high value generated from containment of BBTV. The potentially rapid spread and industry wide consequences of BBTV highlight the industry wide benefit of containment, which is well above the cost of program delivery. Sensitivity testing showed that the investment needed to prevent spread to just 300 ha (2.2% of industry) to be economically justified. While stakeholders noted that the project had not achieved the expected transition to grower lead surveillance and eradication, BA18000 achieved its primary goal of continued containment of BBTV. This generated a NPV of $44.54 million in industry wide farmgate benefits, which is far higher than could be achieved through any cost savings in a PV $2.8 million project. However, if a transition to grower led BBTV containment can be achieved without increasing the risk of spread, it will certainly free up industry RD&E funding for other priority research areas.

The key findings of the BA18000 impact assessment are summarized in Figure 1 below.

Keywords

Impact assessment; cost-benefit analysis; banana; Banana Bunchy Top Virus (BBTV); surveillance, containment

Figure 1. Summary of impact assessment findings

BA18000 BBTV surveillance and education

Total RD&E costs:

- $2.13 million (nominal value)
- 100% R&D levy and Government matching

Research activities:

Between Nov 2017 and Dec 2022, BA18000:

- Conducted targeted surveillance of BBTV and destruction of identified plants in NNSW and SE QLD.
- Collaborated with BBTV spread field research, chemical companies, and state based biosecurity organisations to improve BBTV knowledge and management options.
- Undertook social research, to allow a better understanding of stakeholders affected by BBTV and how they can be more effectively engaged.
- Delivered communication and extension materials to increase knowledge of BBTV incidence and management options among growers and the wider community, and to encourage a greater level of responsibility and ownership of farm level surveillance and control.

Outcomes:

- Ongoing containment of BBTV. A total of 8159 commercial banana plants were detected and destroyed across NSW and Qld, and BBTV was contained within the existing control zones, with approximately 95% of commercial banana production remaining protected.
- Improved resources and stakeholder coordination including through a new *Clean Planting Material Biosecurity Code of Practice 2020* delivered through the project that is supported by a new *Biosecurity (Banana Bunchy Top Virus) Control Order 2021* that was updated with BA18000 support.
- The transition to grower led surveillance was slower than planned with barriers identified through the social research including a large number of smaller landholders and abandoned farms.

Industry economic impacts:

- Reduced the risk of BBTV spreading throughout the Australian banana industry, which would result in rapid productivity losses through reduced yield and increased costs (vector management, surveillance and plant removal).

Socio-economic impacts:

- Preserving the supply of local, fresh and affordable bananas, supporting consumption with associated health and wellbeing benefits.
- Greater security for the economies and communities in which banana production occurs.
- Avoided psychological stress on farmers communities that can result from biosecurity events.

Total attributable benefits and impact:

- Present value (PV @ 5% discount) RD&E costs of $2.80 million.
- PV estimated benefits of $47.34 million.
- Net PV (NPV) of $44.54 million.
- Benefit cost Ratio (BCR) of 16.90:1 with a 90% confidence of a BCR between 6.45:1 and 27.07:1.

Introduction

Evaluating the impacts of levy investments is important to demonstrate the economic, social and environmental benefits realised through investment to levy payers, Government and other industry stakeholders. Understanding impact is also an important step to inform the ongoing investment agenda.

Reflecting its commitment to continuous improvement in the delivery of levy funded research, development and extension (RD&E), Hort Innovation required a series of impact assessments to be carried out annually on a representative sample of investments of its RD&E portfolio. Commencing with MT18011 in 2017-18, the impact assessment program consisted of an annual impact assessment of up to 15 randomly selected Hort Innovation RD&E investments (projects) each year. In line with this ongoing program, Ag Econ was commissioned to deliver the *Horticulture Impact Assessment Program 2020-21 to 2022-23* (MT21015).

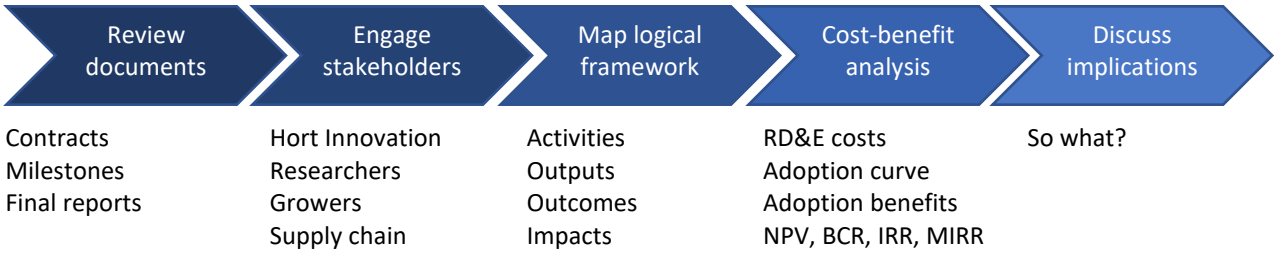
Banana bunchy top virus project (Phase 4) – National surveillance and education (BA18000) was randomly selected in the 2021-22 sample. This report presents the analysis and findings of the project impact assessment.

The report structure starts with the general method of analysis used, followed by the RD&E background and an outline of the impact pathway in a logical framework, then describes the approach used to quantify the identified costs and benefits including any data gaps and limitations to the analysis, presents the results including from the sensitivity analysis, and finally discusses any implications for stakeholders.

General method

The impact assessment built on the impact assessment guidelines of the CRRDC (CRRDC, 2018) and included both qualitative and quantitative analysis. The general method that informed the impact assessment approach is as follows:

1. Review project documentation including project plan, milestone reports, outputs and final report.
2. Discuss the project delivery, adoption and benefits with the Hort Innovation project manager, project researcher/consultant, growers and other relevant stakeholders (see *Stakeholder consultation*).
3. Through a logical framework, qualitatively map the project's impact pathway, including activities, outputs, and outcomes to identify the principal economic, environmental, and social impacts realised through the project
4. Collect available data to quantify the impact pathway and estimate the attributable impacts using cost-benefit analysis (over a maximum 30 years with a 5% discount rate), and then sensitivity test the results to changes in key parameters.
5. Discuss the implications for stakeholders.



The analysis identified and quantified (where possible) the direct and spillover impacts arising from the RD&E. The results did not incorporate the distributional effect of changes to economic equilibrium (supply and demand relationships) which was beyond the scope of the MT21015 impact assessment program. A more detailed discussion of the method can be found in the *MT21015 2023-24 Summary Report* on Hort Innovation project page Horticulture Impact Assessment Program 2020/21 to 2022/23 (MT21015).

Project background

Banana Bunchy Top Virus (BBTV) is the most significant viral disease affecting bananas globally. Affected plants do not produce fruit and the disease is easily spread by banana aphids and infected planting material. If left uncontrolled, plantations can quickly become completely infected and rendered unproductive. The disease entered Australia from Fiji in 1903 via infected planting material and soon wiped out 16,000 hectares of plantations.

The National BBTV Program has been operating since 2009 through a series of Horticulture Australia Limited and Hort

Innovation-funded projects. BA080916 developed a methodological framework for a national BBTV management plan. This was subsequently implemented and updated through Phases 1 to 3 of the management program (BA08020, BA12006, BA15006, BA15007, BA18002). While the program initially sought to eradicate the virus, this was subsequently recognised as infeasible due to the difficulty in controlling the prevalence and spread of the virus among the high number of small-holders, abandon farms, and urban plants in the control zones. As such, the program shifted to focus on containment, which has successfully prevented the virus from spreading beyond the control zones and spreading to the remainder at least 95% of the Australian industry has remained free of BBTV. In 2012, the benefits of exclusion were estimated by Cook et al as being between $15.9-27.0 million per year.

The Banana Strategic Investment Plan (SIP) for 2017-2021 highlighted biosecurity threats such as BBTV as key risks faced by the industry, and prioritised RD&E investments in biosecurity risk reduction.

Following on from the success of Phases 1-3 in containing BBTV, BA18000 was commissioned to continue to contain, and if possible, reduce the prevalence of BBTV within the BBTV biosecurity zone in Southeast Queensland (SE Qld) and the BBTV control zone in northern New South Wales (NNSW). In addition, the project sought to generate delivery efficiencies in project management and organisation to gain budget savings.

BA18000 aligned with the Banana SIP 2022-2026 through:

- Outcome 1: Industry supply, productivity and sustainability. Strategy 3. Improve industry preparedness and resilience to biosecurity threats through better on-farm biosecurity practices, increased surveillance and improved diagnostics.

Project details

VG16064 provided funding to Australian Banana Growers' Council (ABGC) from 2019 to 2022 (Table 1).

Table 1. Project details

Project code	BA18000
Title	Banana bunchy top virus project (Phase 4) – National surveillance and education
Research organization(s)	Australian Banana Growers' Council (ABGC)
Project leader	Dr Rosie Godwin (Australian Banana Growers' Council (ABGC))
Funding period	July 2019 to July 2022
Objective	To prevent Banana Bunchy Top virus (BBTV) from spreading outside the BBTV biosecurity zones in South East Qld and northern NSW where it currently occurs and reduce the incidence of infection within these areas.

Logical framework

The impact pathway linking the project's activities and outputs, and their assessed outcomes and impacts have been laid out in a logical framework (Table 2).

Table 2. Project logical framework detail

- **Targeted surveillance.** Continuing on from and informed by the learnings and incidence levels of BA15006 and BA15007, and the analysis conducted in BA17001, a surveillance program was undertaken contain, control and reduce the impact of BBTV in NNSW and SE QLD. The surveillance included:
  - Commercial banana plantations in NNSW and SE QLD (but not including the Bundaberg region).
  - Non-commercial banana plantings within 0.5 km of an infected farm and those along the northern line of the QLD BBTV zone.
  - Collection and management of surveillance data that could be analysed to inform program monitoring and evaluation, optimise surveillance practices, and retained for other research purposes such as determining disease latency periods.
- **Collaboration**
  - **With BBTV spread field experiments**. Collaborating closely to facilitate bunchy top research being conducted by Assoc Prof John Thomas (UQ), Dr Kathy Crew

RD&E activities… (continued)

(DAF) and Dr Megan Vance (DAF), (Bunchy Top Virologist team from the EcoSciences Precinct, Brisbane) who have begun a series of field experiments at plantation No. 73031 in cooperation with Professor Chris Gilligan from the University of Cambridge, UK, to investigate possible latency and possible spread of the virus from asymptomatic plants in this plantation.

- **With chemical companies**. Proactive chemical control has not been available to a growers. Through BA18000 chemical companies were provided support in field trials to enable the registration of products specifically for aphid control on bananas.
- **With biosecurity authorities.** Working with Biosecurity Queensland (BQ) and Biosecurity NSW to explore regulatory mechanisms to support BBTV management including the development of a clean planting material code of practice, and updating their *Biosecurity (Banana Bunchy Top Virus) Control Order 2017* to make it fit for purpose and harmonized with the Code of Practice. The new control order was issued in 2021. The project also shared non-confidential data to support biosecurity management, and engaged government staff to participate in BBTV extension and training.

- **Social research** conducted by independent consultants *Proof Research* to establish the best way to communicate information and enlist the support of growers to manage BBTV.
- **Education and training.** An extension and communication program was delivered to growers, consultants, collaborating partners and the community in conjunction with the National Extension Project (Qld and NSW) and Banana Industry Communication Project.
  - **Growers and consultants.** Through one-on-one training, formal training events, field days, roadshows and participation at the 2021 Banana Industry Congress, provide education and training in BBTV management, particularly regarding the link between agronomic management and BBTV management. Agronomic management options extended in the project included surveillance and detection; cultural control (clean planting material, de-leafing and de-suckering, and removal of infected plants; and chemical control options.
  - **High Risk Residential Plantings.** Based on the findings from the social research project, a range of communication material were delivered through a variety of media e.g. garden expos, local government newsletters and electronic media.

RD&E outputs

- Surveillance data was captured, analysed and used to inform the project strategy and future research efforts.
- Trained biosecurity staff. The project successfully trained three new BBTV detectors to address future capability risk.
- Social research report
- *The Banana Industry Biosecurity Code of Practice 2020 (Sourcing and planting of banana plants in an area where serios pests are present) was* finalised on August 27 and made available through the ABGC website (https://abgc.org.au/biosecurity/), with the aim of providing detailed guidance to growers on the use of planting material and reasonable and practical steps to minimise associated biosecurity risks and protect the industry.
- Communication and extension resources were developed and disseminated to growers, the community and other stakeholders to support improved BBTV detection and management. may be found in APPENDIX 4 – General stakeholder engagement as well as in the M&E section.

Outcomes

- **Ongoing containment of BBTV**. BBTV was contained within the existing control zones, with approximately 95% of commercial banana production occurs outside of these zones and remaining protected. A total of 8159 commercial banana plants were detected and destroyed across NSW and Qld solely because of the investment in this project. Of those, 6178 were detected in the NSW Control Zone and 1981 in the Queensland Southern Biosecurity Zone. This was achieved through:
  - **Increased BBTV biosecurity capacity and coordination** across key stakeholders: growers in the BBTV control zones, growers outside of the BBTV control zones, communities in high risk residential areas, industry (ABGC) surveillance and extension staff, and biosecurity authorities (BQ and BNSW). However, in some areas the success did not meet industry expectations, particularly around growers taking greater responsibility and more active participation in BBTV management. The social research project identified that most of the infestation recorded in commercial plantations was detected across a small number of properties with similar characteristics (commercially unviable because of issues unrelated to BBTV, older growers transitioning to retirement, mixed cropping with bananas having less priority). These issues were found to result in limitations to transitioning the task and ownership of plant surveillance and destruction to these growers. While the project still reported that properties in the control zone were increasingly completing their own destruction activities in their own time at their own cost, stakeholders noted that the transition to grower led surveillance has been slower than planned, and the issue of ongoing subsidised industry control was increasingly raised by growers outside of the BBTV control zone who were not directly affected by the disease and considered control of the disease a lower priority.
  - **Increased efficiency in BBTV surveillance delivery**. By drawing on existing capacity and expertise in ABCG, and enabling a more efficient coordination with other industry projects delivered by ABGC (communication and extension) the program achieved cost efficiencies compared to earlier phases.
- **Increased ongoing & future research capacity**
  - Through field experiment collaboration with UQ, QDAF and the Bunchy Top Virologist team from the EcoSciences Precinct, Brisbane. Supporting improved BBTV and related research outcomes in the future.
  - Through improved data collection and sharing with research partners to support improved research initiatives.
  - The learnings of BA18000, including the desire for increased grower ownership and responsibility for BBTV control, informed the continuation of BBTV surveillance and control through *Multi-pest surveillance and grower education to manage banana pests and diseases (BA21003)*.

Impacts

- The key outcome for BA18000 was to successfully contain BBTV within the existing control zones, with approximately 95% of commercial banana production occurs outside of these zones and remaining protected, thereby generating the following impacts:
  - [Economic] Reducing the risk of BBTV spreading throughout the Australian banana industry, which would result in rapid productivity losses through reduced yield and increased costs (vector management, surveillance and plant removal).
  - [Socio-economic] Preserving the supply of locally produced fresh and affordable bananas, supporting consumption (Kantar, 2022) with associated health and wellbeing benefits (Mengstu et al 2021, Angelino et al 2019, Mujcic et al 2016).
  - [Socio-economic] Reduced BBTV risk for the banana industry provides greater security for the economies and communities of Tully and Innisfail, Lakeland, and the Atherton Tablelands in Queensland; Darwin in the Northern Territory; the Coffs Harbor and Northern Rivers regions of New South Wales; and the Carnarvon region in Western Australia (The CIE 2023).
  - [Socio-economic] Avoided health and wellbeing costs to farm staff including psychological stress and strains on business and community relationships related to biosecurity events (CSIRO, 2020).

Project costs

The project was funded by Hort Innovation, using the banana research and development levies and contributions from the Australian Government (Table 3). Overhead costs were added to the direct project cost to capture the full value of the RD&E investment.

Nominal investment

Table 3. Project nominal investment

Year end 30 June	Hort Innovation ($) (BA levy and Gov't matching)	Hort Innovation overheads[1] ($)	Other funding ($)	Total nominal cost ($)
2019	245,739	41,789	0	287,528
2020	248,659	38,703	0	287,362
2021	737,217	111,473	0	848,690
2022	245,739	36,343	0	282,082
2023	368,610	54,515	0	423,125
Total	**1,845,964**	**282,824**	**0**	**2,128,787**

1. The overhead and administrative costs were calculated from the Financial Operating Statement of the Banana Fund Annual Reports, averaging 15% for the BA18000 funding period (2019-2023).

Present Value of investment

The nominal total investment cost of $2.13 million identified in Table 3 was adjusted for inflation (ABS, 2024) into a real investment of $2.42 million (2023-24 equivalent values). This was then further adjusted to reflect the time value of money using a real discount rate of 5% (CRRDC 2018), generating a present value (PV) of costs equal to $2.80 million (2023-24 PV). The results were sensitivity tested to changes in the discount rate from 2.5% and 7.5%.

Project impacts

The impact pathways identified in Table 2 were evaluated against available data to determine if their impact could be quantified with a suitable level of confidence.

Impact pathway and available data

A clear impact pathway was identified between the delivery of BA18000 and the reduced industry risk associated with BBTV. Previous research delivered as part of the BBTV control program (BA17001 delivered by UQ, 2019) highlighted that through the management strategies delivered through BA18000, new BBTV infections were likely to be picked up before the epidemic explodes. BA17001 also noted that less stringent management practices would have a high risk of a delayed, rapid spike in infection. Earlier research from Cook et al (2012) highlighted the likely speed of BBTV spread if not controlled and valued the benefits of exclusion at $15.9-$27.0 million per year.

Impacts valued and valuation framework

Given the above, the impact assessment and available data, the analysis focussed on the economic benefits of the continued containment of BBTV.

- [Economic] Reducing the risk of BBTV spreading throughout the Australian banana industry, which would result in rapid productivity losses through reduced yield and increased costs (vector management, surveillance and plant removal).

Drawing on the discussions with stakeholders and available data, a model was developed incorporating the probability of BBTV spreading outside the control zone in a given year, the rate and speed of spread if that were to occur, and the production loss once infection occurs. This model was used to compare a counterfactual "without investment" scenario (no RD&E funded BBTV education, surveillance, and destruction) with a high likelihood that the BBTV would spread through the industry (informed by BA17001, and Cook et al 2012), and a "with investment" scenario with a low likelihood of disease spread (evidenced by the successful control of BBTV for the duration of BA18000). The reduction in risk occurred in the period 2019-20 to 2022-23 (being the window of project delivery); however, the benefits of this risk reduction flowed beyond the project period as once established outside the control zone it would be increasingly unlikely for containment to be re-established. Finally, the attribution of the total identified impact to BA18000 was considered in the context of the learnings from the preceding phases 1-3, and the contributions of other factors in BBTV control (such as biosecurity regulation).

Impacts unable to be valued

The following impacts were not able to be quantified for the reasons outlined:

- [Socio-economic] Fresh, affordable, and locally grown are three of the key drivers in Australian consumer purchasing behaviour for fruit, vegetable and nuts (Kantar, 2022). Further, there is a recognised link between health and wellbeing benefits and banana consumption (Mengstu et al 2021) and fruit and vegetable consumption more broadly (Angelino et al 2019, Mujcic et al 2016). However, to quantify the benefit of increased banana consumption (or avoided decreases in banana consumption) in the context of cost benefit analysis requires a clear relationship between unit consumption and unit health and wellbeing, as well as a dollar value for unit health and wellbeing changes. These relationships and values could not be confidently estimated through available data or stakeholder consultation. Furthermore, while Australian biosecurity currently prevents banana imports, a significant and long term decline in Australian banana production from BBTV would likely result in import access, offsetting some or all of this benefit depending on consumer preferences for imported bananas.
- [Socio-economic] Greater social and economic resilience for farm and local communities. The CIE (2023) highlighted the flow-on (spillover) effects of the banana industry for regional economies, particularly around the communities of Tully, Innisfail, Lakeland, and the Atherton Tablelands in Queensland; Darwin in the Northern Territory; the Coffs Harbor and Northern Rivers regions of New South Wales; and the Carnarvon region in Western Australia. By supporting increased industry productivity and sustainability, the project supports a corresponding increase in spillovers to local communities. While this analysis was able to quantify the direct impacts for banana industry production and value, the flow-on effects require additional analysis in economic models that capture regional and national linkages, which are beyond the scope of the R&D impact assessment program (CRRDC 2018). Increased resilience also relates to avoided health and wellbeing costs associated with biosecurity events. These health and wellbeing effects, such as avoided or reduced psychological stress that can affect growers and their communities, may be more profound than the direct economic impact (CSIRO, 2020 and CSIRO 2021). The CSIRO research also notes that the health and wellbeing affects are harder to quantify than economic impacts, which is consistent with the lack of data identified through this analysis to value health and wellbeing effects.

Data and assumptions

The required data relating to the impact pathway was collected from the project documents and other relevant resources (Table 4). Where available, actual data was applied to the relevant years, with estimates applied for any data gaps and projections into the future based on analytical techniques (for example correlations and trend analysis), or stakeholder estimates, or both. A data range was incorporated to reflect underlying risk and uncertainty. This was particularly relevant where estimates were needed due to data gaps, and where projections were made into the future. These ranges were then analysed through sensitivity testing (see *Results*).

Table 4. Summary of data and assumptions for impact valuation

Variable	Value	Source & comment
General data and assumptions		
Discount rate	5% (± 50%)	CRRDC Guidelines (2018).
Baseline area infected (ha)	1.7 ha	Annual average of the number of infected plants (2864) between 2020-2022 (BA18000 final report) divided by average plant density of 1700 plants per hectare (QDAF 2018).
Likelihood of spread (without BA18000)	95% (± 5%)	Analyst estimate based on the high probability of spread uncontrolled spread identified in BA17001.
Likelihood of spread with BA18000	5% (± 100%)	Analyst estimate based on the successful containment of BBTV during the project indicating a very low, but not necessarily zero probability of spread.
Total area at risk of BBTV spread (ha)	6,000ha to 11,000 ha over 30 years	Derived from Cook et al (2012), compared to total industry area of 13,541 ha (AARSC 2024). See *Appendix A. Key data and projections.*
Production consequences of BBTV spread	100%	Banana plants infected with BBTV rarely produce fruit. If fruit is produced it is small, deformed and unmarketable (NSW DPI, 2024). Average yield across plant crop and ratoon crops was 29-31 t/ha (five year average of ABS Agricultural Commodities (ABS 2023)).
Price outlook ($/kg)	$1.71/kg (+6%, -17%)	11 year average farmgate price (Hort Innovation 2024), adjusted for inflation (ABS 2024). See *Appendix A. Key data and projections.*
Production costs ($/kg)	$1.34/kg	Estimated variable costs taken from Pinnacle Agribusiness (2018) and adjusted to 2023-24 figures (ABS 2024)
Outcome attribution	75% (± 33%)	Discussions with stakeholder indicated a high attribution to the BBTV surveillance program in containing the virus. A baseline estimate of 75% attribution was used, considering the contribution of growers, community, concurrent R&D extension projects, biosecurity authorities, as well as learnings carried through from phases 1-3.
R&D counterfactual	75% (± 100%)	Discussions with stakeholder indicated a low likelihood that BBTV surveillance could be effectively undertaken without banana industry levy investments.

Results

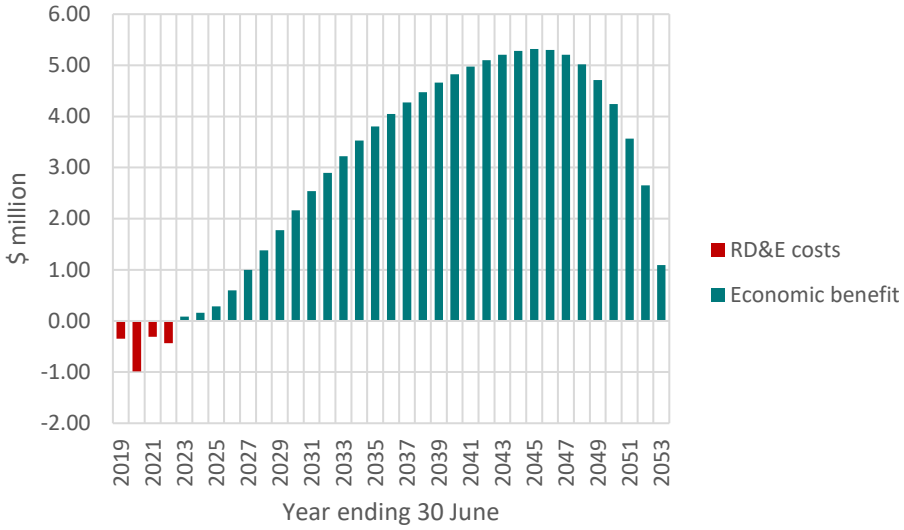
The analysis identified PV costs (PVC) of $2.80 million (2023-24 PV) between 2018-19 and 2022-23, and estimated PV benefits (PVB) of $47.34 million (2023-24 PV) accruing between 2021-22 and 2052-53 (Table 5). When combined, these costs and benefits generate a net present value (NPV) of $44.54 million, an estimated benefit-cost ratio (BCR) of 16.90 to 1, an internal rate of return (IRR) of 29% and a modified internal rate of return (MIRR) of 14%.

Table 5. Impact metrics for the total investment in project BA18000

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	2.80	2.80	2.80	2.80	2.80	2.80	2.80
PVB ($m)	0.27	4.47	14.09	25.34	35.89	44.25	47.34
NPV ($m)	-2.53	1.67	11.29	22.54	33.09	41.45	44.54
BCR	0.10	1.59	5.03	9.05	12.81	15.80	16.90
IRR	Negative	7%	24%	28%	29%	29%	29%
MIRR	Negative	6%	17%	18%	17%	15%	14%

Figure 2 shows the annual undiscounted benefit and cost cash flows attributed to BA18000.

Figure 2. Annual cash flow of undiscounted total benefits and total investment costs

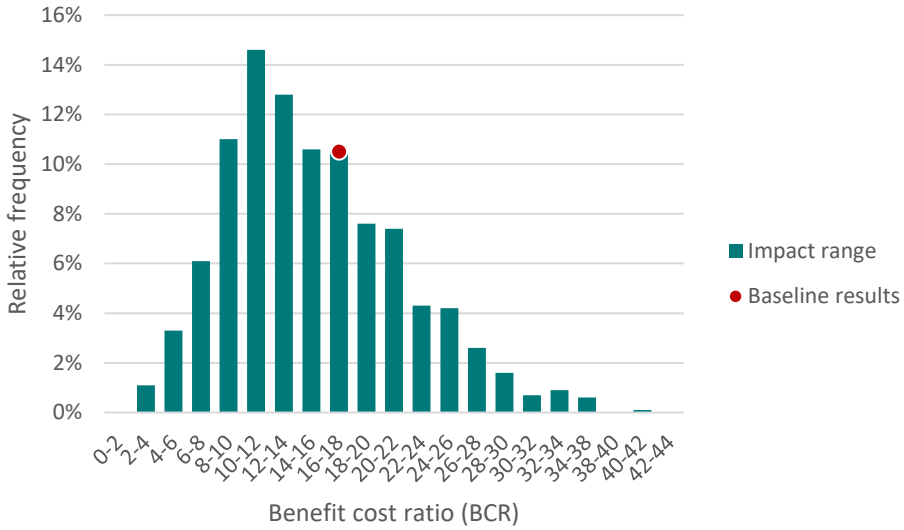


Sensitivity analysis

Given the risk and uncertainty associated with a number of underlying modelling variables, the potential model variation was estimated and drivers of variation identified. The sensitivity testing used @Risk stochastic modelling to incorporate the combined effect of changing all variables across their full ranges over 1000 simulations. This process showed:

- **Impact variation (Figure 3)**. Compared to the baseline BCR or 16.90:1, the 1000 simulation showed a potential BCR range of between 2.70:1 and 38.47:1, with 90% of results falling between 6.45:1 and 27.07:1 (i.e. excluding the low probability tails), and a simulation average of 15.23:1 (below the baseline results). These results gave a high level of confidence that the investment will generate a positive impact.

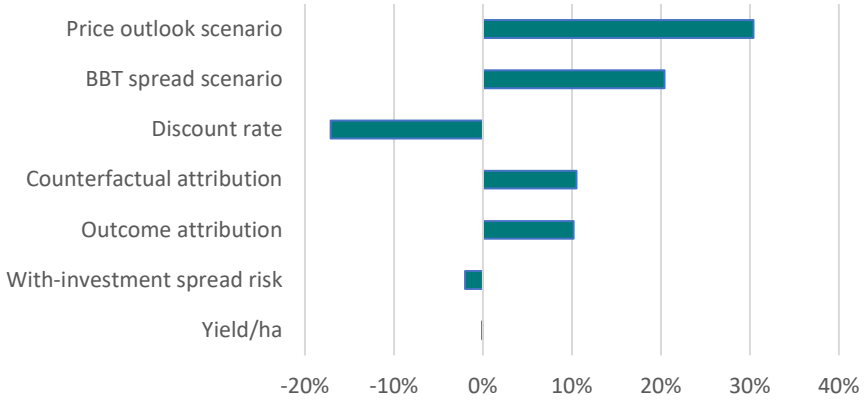
Figure 3. Impact variation in results over 1000 simulations



- **Contribution to variance (Figure** 4). Contribution to variance is a measure of how much a variable contributes to the total variance of an output. Contribution to variance also shows whether a variable is positively or negatively correlated with impact. A negative contribution to variance, with bar extending to the left, indicates that this input has a negative effect on BCR: increasing this input will decrease the impact. The price outlook scenario had the largest contribution to variance, with higher prices increasing the returns from avoided crop losses. The breakeven price is effectively the cost of production; as long as banana growers are making money there is value in containing BBTV

spread. The BBTV spread scenario had the second highest contribution to variance. A faster and higher level of disease spread results in more damage to industry, and therefore increases the returns of containment. The project demonstrates a positive impact if it prevents the spread of BBTV to at least 300 ha (2.2% of industry area), well below the likely area of spread identified by Cook et al (2012). The discount rate had the third highest contribution to variance, but with a negative correlation with investment impact. The breakeven discount rate is reflected in the IRR (29%), or the MIRR (14%) if we assume that generated cashflows are reinvested at the risk-free discount rate.

Figure 4. Contribution to variance



Implications and learnings

A clear impact pathway was identified between the delivery of BA18000 and the reduced industry risk associated with BBTV. Previous research delivered as part of the BBTV control program (BA17001 delivered by UQ, 2019) highlighted that through the management strategies delivered through BA18000, new BBTV infections were likely to be picked up before the epidemic explodes. BA17001 also noted that less stringent management practices would have a high risk of a delayed, rapid spike in infection.

The model developed in the analysis quantified the benefit of BA18000 in reducing the risk of BBTV spread during the period 2019-20 to 2022-23. Without the project (the counterfactual) there would be a high likelihood of BBTV spread through industry, whereas the delivery of BA18000 successfully reduced the risk to the extent that the disease did not spread beyond the containment area. The rate of spread was based on previous analysis conducted by Cook et al (2012), which highlighted (in congruence with BA17001) the potential high rate of spread across industry.

From this approach, the baseline results showed a positive industry farmgate economic impact with a BCR of 16.90:1. The annual average industry farmgate benefit was $3.04 million per year reflecting lost profit. Considering the total production value provides an indication of the broader avoided economic losses, which equated to an average $14.07 million per year, just below the containment value range of $15.9-$27.0 million per year estimated by Cook et al (2012). These broader losses would accrue to the supply chain and local communities in which the banana industry operates.

Sensitivity testing showed a very wide potential impact range of between 2.70:1 and 38.47:1, with 90% of results falling between 6.45:1 and 27.07:1 giving a high level of confidence that the investment generated a positive impact. The variation was driven primarily by banana price, as well as the potential speed and area of spread of BBTV without containment. There was generally a high level of data available for the analysis; however, the model still displayed a wide variation in results reflecting the complexity of estimating BBTV spread and the uncertainty over the banana price outlook.

The analysis re-enforces the earlier estimates of the high value generated from containment of BBTV. The potentially rapid spread and industry wide consequences of BBTV highlight the industry wide benefit of containment, which is well above the cost of program delivery. Indeed, the sensitivity testing showed that the investment needed to prevent spread to just 300 ha (2.2% of industry) to be economically justified. While stakeholders noted that the project had not achieved the expected transition to grower lead surveillance and eradication, BA18000 achieved its primary goal of continued containment of BBTV. This generated a NPV of $44.54 million in industry wide farmgate benefits, which is far higher than could be achieved through any cost savings in a PV $2.8 million project. However, if a transition to grower led BBTV containment can be achieved without increasing the risk of spread, it will certainly free up industry RD&E funding for other priority research areas.

Stakeholder consultation

Where possible, Ag Econ sought to engage multiple stakeholders across key areas of the logical framework and impact pathway to augment existing information and data sources, and reduce any uncertainty or bias from individual stakeholders. All stakeholders were engaged through telephone or online meetings, with follow up emails as necessary. Consultation followed a semi-structured approach in line with broad topics relating to the impact pathway and associated data requirements. Table 6 outlines the stakeholders consulted as part of this impact assessment and the topics on which they were consulted.

Table 6. Stakeholder consultation by theme

Stakeholder details		Consultation topics					
Stakeholder and organisation	**Stakeholder type**	**Related research**	**Research inputs**	**Research outputs**	**Research immediate outcomes**	**Follow on research**	**Impact areas and data**
Araz Solomon, Hort Innovation, R&D manager Integrated Pest and Disease Management	RD&E process owner / manager				✓	✓	✓
Rosie Godwin, ABGC, R&D manager	RD&E practitioner (Project lead)	✓	✓	✓	✓	✓	✓
Grant Telford, ABGC, R&D manager	RD&E practitioner	✓	✓	✓	✓	✓	✓

Glossary of economic terms

Benefit-cost ratio (BCR)	The ratio of the present value of investment benefits to the present value of investment costs.
Cost-benefit analysis (CBA)	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Direct Effects	Impacts generated for the funding industry as a result of adoption of the RD&E outputs and recommendations, typically farm level outcomes relating to productivity and risk.
Discounting and Present Values	The process of relating the costs and benefits of an investment to a base year to reflect the time value of money or opportunity cost of RD&E investment. The analysis applies a real discount rate of 5% in line with CRRDC Guidelines (CRRDC 2018) with results sensitivity tested at discount rates of 2.5% and 7.5%.
Economic Equilibrium	Due to a market's underlying supply and demand curves, changes in supply will have an impact on price and vice-versa. The Economic Equilibrium is the point at which market supply and price are balanced. Estimating the magnitude of market response to changes in supply or demand is a complex and demanding task that is considered beyond the scope of most CRRDC Impact Assessments (CRRDC 2018).
Gross Margin (GM)	The difference between revenue and cost of goods sold, applied on a per hectare basis and excluding fixed or overhead costs such as labour and interest payments.
Internal rate of return (IRR)	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits = present value of costs.
Modified internal rate of return (MIRR)	The internal rate of return of an investment that is modified so that the cash inflows generated from an investment are re-invested at the rate of the cost of capital (in this case the discount rate).
Net present value (NPV)	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Nominal and real values	Nominal values reflect the actual values in a given year (e.g. contracted RD&E expenses). These are converted to real (inflation adjusted) values to make them comparable across time.
Spillover Effects	Impacts generated for stakeholders who did not fund the RD&E, including other agricultural industries, consumers, communities, and the environment.

Abbreviations

BBTV Banana Bunchy Top Virus

RD&E Research, Development and Extension

SIP Strategic Investment Plan

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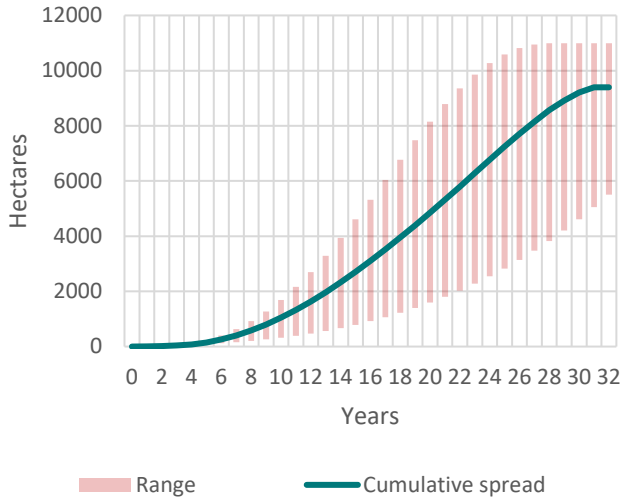
Appendix A. Key data and projections

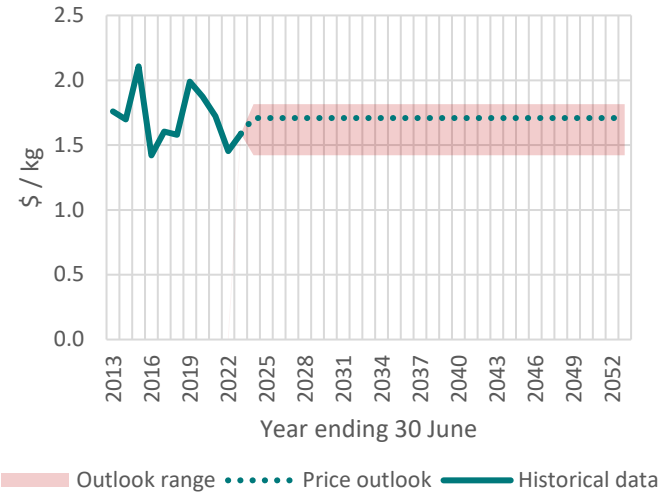
- The potential speed and area of spread of BBTV (Figure 5) was estimated from Cook et al (2012), reaching a maximum of 11,000 ha (81% of industry).
- Banana farmgate prices (Figure 6) were projected based on 2012-13 to 2022-23 Hort Stats Handbook data (Hort Innovation 2024), which were adjusted for inflation into real figures (using ABS 2024). The baseline projection was for a banana price of $1.72/kg (based on the 11 year average), with a range of $1.42/kg (11 year minimum) and $1.82/kg (75th percentile over 11 years, removing short term price spikes during cyclones).

Figure 5. Estimated spread of BBTV without control



Source: Cook et al (2012).

Figure 6. Real banana prices



Source: Hort Innovation (2024)

Ends.