An Impact Assessment of CRDC myBMP Investments: July 2012 to March 2016

Draft Report

To

The Cotton Research and Development Corporation

Agtrans Research

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Acknowledgments

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Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACRI	Australian Cotton Research Institute
BCI	Better Cotton Initiative
BCR	Benefit-Cost Ratio
BMP	Best Management Practice
CBA	Cost-Benefit Analysis
CottASSIST	CottASSIST is a group of web tools designed to deliver the latest cotton research and integrate up-to-date information and assist with cotton management decisions.
Cotton LEADS™	Cotton LEADS™ is a program committed to increasing awareness of responsible cotton production among program partners and the cotton industry.
COTTONpak	COTTONpak refers to industry CDs containing all the major decision support systems developed for the cotton industry.
CPLM	Centre Pivot and Lateral Move
CRC	Cooperative Research Centre
CRDC	Cotton Research and Development Corporation
CRRDC	Council of Rural Research and Development Corporations
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF Qld	Queensland Department of Agriculture and Fisheries
DAWR	Department of Agriculture and Water Resources
GDP	Gross Domestic Product
GPWUI	Gross Production Water Use Index
ha	Hectare
HR	Human Resources
IPM	Integrated Pest Management
IRR	Internal Rate of Return
IWM	Integrated Weed Management
IWUI	Irrigation Water Use Index
KPIs	Key Performance Indicators
LEFT	Last Effective Flower Tool
MIRR	Modified Internal Rate of Return
myBMP	myBMP is the cotton industry's best management practice assurance mechanism for growers.
NPV	Net Present Value
NRM	Natural Resource Management
NSW DPI	New South Wales Department of Primary Industries
NutriLOGIC	NutriLOGIC is a web based decision support tool for interpreting soil and plant tissue results and calculating nutrition requirements.
OCS	Office of the Chief Scientist
PVB	Present Value of Benefits
PVC	Present Value of Costs
Qld DEEDI	Queensland Department of Employment, Economic Development and Innovation
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
SOILpak	SOILpak is a best practice soil management manual for the Australian cotton industry.
SPRAYpak	SPRAYpak is a guide for pest management in cotton farming systems.
TIMS	Transgenic and Insect Management
WATERpak	WATERpak is a guide for irrigation management in cotton and grain farming systems.
WEEDpak	WEEDpak is a guide for weed management in cotton farming systems.
WHS	Workplace Health and Safety
WUE	Water Use Efficiency

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Executive Summary

The Investment
This report presents the results of an impact assessment of a cluster of six myBMP projects funded by the Cotton Research and Development Corporation (CRDC) over the years ending June 2012 to 2016. In addition to CRDC funding (a combination of statutory levies paid by industry participants and matching Commonwealth funding), other resources were provided by research organisation contributions.

Methods
The six individual projects were first analysed qualitatively within a logical framework that considered project rationale, objectives, activities/outputs, outcomes, and impacts. Project Principal Investigators made comments and inputs to these logical frameworks. Some of the impacts identified through this process were then valued in financial terms. Benefits were calculated for a range of time frames up to 30 years from the year of last investment (2015/16). Past and future cash flows in 2016/17 $ terms were discounted to the year 2016/17 using a discount rate of 5% to estimate investment criteria. Investment criteria reported included Present Value of Benefits, Present Value of Costs, Net Present Value, Benefit-Cost Ratio, Internal Rate of Return, and the Modified Internal Rate of Return.

Impacts
Most the impacts identified were economic in nature, however some social and environmental impacts also were identified. Some of the cluster impacts were valued in monetary terms; the decision not to value certain impacts was due either to a high degree of uncertainty surrounding potential impacts, a shortage of necessary data, or the likely low relative significance of the benefit compared to those that were valued. It is expected the Australian cotton growing industry will be the primary beneficiary of the investment, as will the natural resource environment. Regional communities, and other cropping industries are also expected to benefit.

Investment Criteria
Total funding from all sources for all six projects totalled $6.39 million (present value terms). The benefits from the investment were valued at $58.15 million (present value terms). This gave a net present value of $51.76 million, a benefit-cost ratio of 9.10 to 1, an internal rate of return of 31.28% and a modified internal rate of return of 12.52%.

1. Introduction

Background to Impact Assessment

In calendar 2016 and 2017 CRDC has been carrying out a series of impact assessments of some of their principal Research, Development and Extension (RD&E) investments. The primary purpose of these impact assessments is to assist with portfolio management and provide accountability to the CRDC Board, its levy paying industry and the Australian Government. The results of the impact assessments can also can be used as inputs into the development and/or assessments of further research investments in a sustainability context.

A further purpose of the CRDC impact assessments is to contribute to a process being undertaken for the Council of Rural Research & Development Corporations (CRRDC). This process aims to demonstrate the impacts and benefits that have emerged or are likely to emerge from the 15 Rural Research and Development Corporations (RDCs) including producer-owned companies. Valuation of these impacts, along with identification of investment expenditure, is required to demonstrate the RDCs' contribution to the Australian rural industry as well as environmental and social impacts to Australia.

The Importance of myBMP Research

myBMP is a voluntary farm and environmental management system which provides self-assessment mechanisms, practical tools and auditing processes to ensure that Australian cotton is produced according to best management practice (myBMP, n.d.). Growers can also choose to be professionally audited and certified as myBMP accredited cotton growers. Adoption of myBMP supports the risk management and social licence requirements of the cotton industry. This is particularly so as cotton production involves the use of significant amounts of water and chemicals. Thus, the production process needs to be efficiently managed to moderate detrimental environmental impacts which if not curbed may lead to loss of grower incomes and/or loss of industry social licence.

In using myBMP information and tools, cotton growers can improve on-farm performance through:

- Better managing business and production risk, through use of up-to-date effective solutions to deal with pests, weeds, water use efficiency, and legal requirements, among others.
- Maximising potential market advantages, such as access to premium cotton prices afforded by the Better Cotton Initiative (BCI).
- Demonstrating responsible and sustainable natural resource management to the community, through myBMP certification, BCI and/or Cotton LEADS ™ certification.

The myBMP information is categorised into 10 key modules for growers, these are:

- *Biosecurity* - for avoidance, management and control of pests and diseases
- *Energy and Input Efficiency* - for more efficient energy inputs such as electricity, fuel and fertilisers
- *Fibre Quality* - for growing the best quality cotton possible
- *Human Resources and Workplace Health and Safety* - helps growers manage employees and contractors whilst providing a safe and compliant workplace
- *Integrated Pest Management (IPM)* - for management of pests, weeds and diseases
- *Sustainable Natural Landscape* - for managing the vegetative and riparian assets on the farm

- *Pesticide Management* - for all aspects of pesticide management, storage and use on farm
- *Petrochemical Storage and Handling* - for managing fuels and lubricants on farm
- *Soil Health* - for maintaining and/or improving soil quality and fertility
- *Water Management* - covering water quality, efficiency of storage and distribution for both dryland and irrigated farming practices

2. Methods

The evaluation approach follows general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including RDCs, Cooperative Research Centres (CRCs) and some Universities. The impact assessment uses Cost-Benefit Analysis (CBA). This entails both qualitative and quantitative approaches that are in accord with the evaluation guidelines of the Council of Research and Development Corporations (CRRDC, 2014).

The assessment process commenced with the identification and brief description of each of the six projects in terms of their objectives, activities & outputs, outcomes, and impacts. The individual project outcomes and impacts were then integrated and described at the aggregate cluster level. The principal economic, environmental and social impacts at the cluster level were then summarised in a triple bottom line table.

Some, but not all, of the impacts identified were then valued in monetary terms. The decision not to value certain impacts was made based on a range of factors including the difficulty of linking some project outcomes to impacts, a shortage of evidence to fully support the impact, or a high degree of uncertainty limiting reasonably accurate evaluation. However, the impacts valued are deemed to represent a conservative estimate of the value of the principal benefits derived from the cluster investment. The valued impacts were then compared with the investment costs for the whole cluster. This allowed aggregate investment criteria to be produced for the investment in the cluster of the six myBMP projects.

3. Description of Projects

Table 1 provides a list of the project codes and titles of all six projects defined in the population of the myBMP Cluster.

Table 1: Projects Included in the Population of the myBMP Cluster

Project Code	Project Title
CSP1201	Support the Adoption of myBMP for Improved Cotton Crop Productivity and Sustainability by Linking Research, Extension and myBMP
DWC1201	WATERpak Update and myBMP Integration
DAN1305	Updating and Expanding WEEDpak in Support of the Cotton Industry and myBMP
RRR1402	myBMP Lead Certification
INNOV229	Sustainable Australian Cotton Production Supplying International Markets
CRDC1428	Consultancy Agreement: Review of the Content in and Between the myBMP Modules

A full description of each of the six projects is presented in Tables 2 to 7. The projects are summarised in a logical framework format (rationale, objectives, activities and outputs, outcomes and impacts).

Table 2: Logical Framework for Project CSP1201

CSP1201: Support the Adoption of myBMP for Improved Cotton Crop Productivity and Sustainability by Linking Research, Extension and myBMP	
Project details	Organisation: CSIRO Plant Industry Period: July 2011 to June 2014 Principal investigator: Sandra Williams (nee Deutscher)
Rationale	A strong link between the research community and the cotton industry's extension is fundamental to industry success. One way to integrate research outputs with complex on-farm decision making is through the use of up-to-date and easy to access web tools. The availability of web tools provides supporting resources for myBMP and facilitates the adoption of best management practices by the cotton industry. There was, therefore, a need to support links between research outputs and extension work, and provide updated information that is easy to access to support both myBMP and CottASSIST.
Objectives	1. To facilitate the linkage and integration of research outputs and outcomes with myBMP. 2. To support the delivery of myBMP to the cotton industry. 3. To facilitate the development of timely, relevant and consistent information from research to support myBMP and respond to urgent/emerging issues (with active participation in the industry's Development and Delivery team). 4. To develop a market description of existing CottASSIST database information and web tools and prioritise those with the best fit for integration with or links to myBMP. 5. To develop a forward plan for delivering research, or supporting its uptake through the development of decision tools for crop production efficiency through appropriate formats such as web tools and phone applications (with active participation in the industry's Development and Delivery team). 6. To maintain functionality and improve CottASSIST website capabilities.
Activities and Outputs	• The CottASSIST website was relocated to a new 2008 Windows Server, which provided for speed and capacity improvements, and allowed for the use of the latest .NET web technologies. • Web browser incompatibility issues were addressed for all CottASSIST pages. • Enhanced security (SSL authentication) was activated on the website, and was applied to all web addresses on the new server. • The CottASSIST website officially received its own domain name (www.cottassist.com.au) and was separated from the old CRDC web address. • The Principal Investigator and another team member, Loretta Clancy, liaised frequently with research teams, the CottonInfo team, growers and consultants to develop new information and decision tools to update industry (strategically and tactically), pre-empt possible future industry issues, and/or respond to current issues. • A 'contact us' page was added to the CottASSIST webpage for users to contact the Principal Investigator for help, feedback or general enquiries. • The Principal Investigator assisted with the annual revision of practices and content in myBMP to ensure its relevance and credibility. Through this mechanism the project supported the individual specialists to revise 'best practice' and measures of attaining implementation. • The project promoted myBMP at the 2012 and 2014 Australian Cotton Conference using a CottASSIST poster and factsheet. • Team members developed, facilitated and/or assisted with the production of the following extension material and activities: o Co-ordinated and co-edited the *Pest and Beneficials in Australian Cotton Landscapes;* this was made available to the industry as a hardcopy as well as

	online. This document has been widely cited within the industry and in peer-reviewed journal articles (Sandra Williams, pers. comm., 2017). o Coordinated a review of *The Integrated Pest Management Guidelines* (brief version) for cotton production systems. o Assisted with the development of fact sheets for soil testing, petiole testing and leaf testing. o Contributed to a review of the pest related sections in the *Cotton Disease Symptoms Guide*. o Reviewed several chapters of *The Australian Cotton Production Manual* as well as jointly writing chapters including '*Using Mepiquat Chloride*' and '*The Cotton Plant*'. o Liaised with many researchers and CRC staff to edit numerous chapters of '*The Australian cotton water story'*. o Wrote articles published by the Spotlight Magazine featuring CottASSIST, the Upper Namoi researcher tour and the CottASSIST Aphid Yield Loss Tool. o Undertook two successful researcher farm visits. The first visit was in November 2012 to the Upper Namoi (collaborating extension officer Kirrily Blomfield) and the second in the Lower Namoi in Nov 2013 (collaborating extension officer Geoff Hunter). o Helped to coordinate and conduct training on insect identification clinics (2011/12, 2012/13 and 2013/14) for the Auscott Narrabri bug checking team and the Macquarie Valley consultants and bug checkers (2011/12, 2012/13 and 2013/14). o Reviewed and/or edited material for the CottonInfo Team such as: the Nitrogen Management Trial protocol, a Silverleaf Whitefly fact sheet, and the IPM guidelines in the Cotton Pest Management Guide o Coordinated Australian Cotton Research Institute (ACRI) large group tours for Tocal Agricultural College students (40+) and Kempsey High School Agriculture students (20+); this included organising talks from various researchers. • Developed a detailed description of each of the CottASSIST tools, their usage and relationship with myBMP; these CottASSIST tools included: Aphid Yield Loss, Crop Development Tool, Day Degree Report, Diapause/ Emergence Tool, Last Effective Flower Tool, Mite Yield Loss Tool, NutriLOGIC, Seasonal Climate Analysis, Silverleaf Whitefly Threshold Matrix Tool, and Water Quality Tool. • Some of the specific improvements that were undertaken for CottASSIST tools are as follows: o Modification of the Crop Development Tool to include the 'plants per metre' measurement as part of the sample information, allowing users to analyse crop information on a plant basis. o Inclusion of a Crop to Crop Comparison page in the Crop Development Tool; this addition allows users to compare two crops (either the same crop from different seasons, or two different crops from the any season). o The Crop Status page in the Crop Development Tool was modified to display long term average day degrees alongside the current day degrees. o Modification of NutriLOGIC to allow users to save and retrieve more than one sample in the soil and leaf areas. o Modification of The Seasonal Climate Analysis tool to include a Long Term Seasonal Summary option, allowing users to be able to analyse data from 1957 to current (in one report) at a seasonal level. • Micronaire Prediction and Comparison tools were completed and made available on the CottASSIST website. The prediction tool is for analysing data for an existing crop, and the comparison tool compares the impact on micronaire for five planting dates (within a 4-week date range), or five years for the same planting date. • Produced a new version of the *Helicoverpa armigera* Diapause Induction and Moth Emergence tool. • A pilot project on mobile development was started by team members to test devices and entry modes best suited for collection of data in the field. • The CottASSIST Climate Change component was expanded to include a new version of the Last Effective Flower Tool (LEFT), which has been designed to work with predicted future climate change Climate Data.

	• A new Climate Change component was created for initial use by cotton researchers. • Team members prepared and delivered information through the cotton industry's major publications. Some relevant publications included the following: o Luo, Q., Bange, M.P. and Clancy, L. (2014). Cotton crop phenology in a new temperature regime. *Ecological Modelling*. 285: 22-29. o Williams, S.D., Bange, M.P., Constable, G., Clancy, L. (2013). A new online tool for predicting cotton micronaire. *The Australian Cottongrower*, 34(7). pp.46-48. o Trindall J, Roth G, Williams S, Harris G and Wiggington D. 2012. The Australian cotton water story. A decade of Research & Development 2002 – 12. *Cotton Catchment Communities CRC Limited*. Greenmount Press, Toowoomba. o Williams S, Bange, M and Constable G. 2012. Using Mepiquate Chloride (Pix). Chapter from Australian Cotton Production Manual 2012. *Cotton Research and Development Corporation*. Greenmount Press, Toowoomba. o Williams S and Bange, M. 2013. Introduction to a cotton plant. Chapter from Australian Cotton Production Manual 2013. *Cotton Research and Development Corporation*. Greenmount Press, Toowoomba. o Williams, S and Clancy L. 2012. CottASSIST web tool – the best science – the best solution. The Australian Cottongrower. Feb - Mar 2012. pp 12-13. o Constable, G, Stiller, W., Clancy L. (2011) Dryland cotton water efficiency on the increase. *The Australian Cottongrower*, 32: pp17-19
Outcomes	• Through industry interactions, enhancements to CottASSIST tools were identified and implemented. • The project significantly contributed to the translation of research outputs to management practices for many of the myBMP modules. • The project delivered research outputs through resources such as the Cotton Production Manual and various best management practice guides. • The project made a contribution to efficient communication of research information to cotton growers and consultants. • Information on the *Helicoverpa armigera* Diapause Induction and Moth Emergence tool has been used at the Transgenic and Insect Management Strategies (TIMS) committee to discuss future resistance management plans for Bollgard III. • The project provided researchers with access to the new Climate Change component of Day Degree Tool reports. • The CottASSIST page views picked to 37,318 for the month of June 2012 from 27,298 for the same month the previous year (prior to project commencement). By February 2017 the page views had dropped to 30,700 by still higher than views before the project commenced (Sandra Williams, pers. comm., 2017). • Visits to the CottASSIST website increased from about 2,000 per month in June 2010 to 4,906 in February 2017 (Sandra Williams, pers. comm., 2017). • Unique visits increased from 801 in June 2010 to 2,536 users in February 2017and page views increased from 15,523 in June 2010 to 30,700 by February 2017 (Sandra Williams, pers. comm., 2017). • The CottASSIST tools improved ease of access to current and best management industry practices. The two most popular CottASSIST tools have been the Day Degree Calculator and the Crop Development Tool. Both tools promote best practice in crop management by assisting the user in tracking the growth of their crop compared to the theoretical optimum growth. Knowing how the crop is tracking will help inform a range of decisions in areas of nutrition, irrigation, growth regulation and pest management. The impact of these two tools for the industry is the increase in understanding how the cotton crop grows. This basic understanding is critical for all management decisions (Sandra Williams, pers. comm., 2017).
Impacts	• Enhanced adoption of myBMP in the cotton industry. • Improved and timely access to research information by growers and industry stakeholders. • Better informed grower decision making with regards to fertiliser needs, irrigation, growth regulation and pest management.

	• Contribution to improved profits for cotton growers from enhanced cotton quality and productivity. • Enhanced support to industry research capacity.

Table 3: Logical Framework for Project DWC1201

DWC1201: WATERpak Update and myBMP Integration	
Project details	Organisation: DW Consulting Services Period: November 2011 to July 2013 Principal investigator: David Wigginton
Rationale	WATERpak, a compendium of water and irrigation research was first released in 2004 and has been a significant resource for the cotton industry for over a decade. Grains related information was added to WATERpak in 2008. Over this time, there has been a significant change in irrigation and water management research. myBMP, the cotton industry farm and environmental management system was also launched online. There was, therefore, a need to update WATERpak to ensure that growers and industry consultants have access to the latest research information and that they continue making improvements in water use efficiency.
Objectives	1. To convene a WATERpak Update Committee to guide the update process. 2. To assess the relevance of the existing WATERpak material and identify new research to be included. 3. To provide advice to the myBMP team regarding practices in the myBMP water module and links to WATERpak materials. 4. To update the existing WATERpak and add new material, including specific material on grains irrigation. 5. To develop material for inclusion in the Cotton Water Story publication and assist with publication editing.
Activities and Outputs	• A WATERpak Update Committee was convened, it was made up of: David Wigginton, Graham Harris, Tracey Leven, Jim Wark, David Larsen, Janelle Montgomery, Rod Jackson, Peter Smith, Michael Bange and Rose Brodrick. • The committee met and reviewed results from a previous meeting from the Water Smart Cotton and Grains project. • The committee decided on specific chapters that should be added, reduced, removed or merged and also decided that the new edition of WATERpak should be produced only in electronic format, but with the ability to provide printed copies in the future if desired. • The project manager organised various in-kind resources, particularly those of Qld DEEDI (now DAF Qld) to perform updates as required. The project manager undertook various updates where in-kind resources could not be identified and also undertook significant editing of all WATERpak chapters. • Authors were provided with relevant myBMP practices to ensure supporting material was included in the WATERpak chapters. • The edited chapters were shared with a graphic design company for desktop publishing, with additional funding provided by Qld DEEDI through the Healthy Headwaters Program. • An updated WATERpak edition was produced and published online http://www.cottoninfo.com.au/publications/waterpak • The updated WATERpak edition covers: concept of efficient irrigation, irrigation management for cotton and grains, irrigation systems and catchment scale water quality impacts. • The new WATERpak design accommodates online usage and readability. There are links to other online information sources embedded in the compendium. • New extension related information includes: deep drainage, storage and channels, pumps, irrigation scheduling, limited water situations, tools for irrigation, irrigation management of cotton, irrigation management of grain crops, irrigation system selection, surface irrigation and fertigation.
Outcomes	• Development and provision of a resource for growers and other industry stakeholders to support and improve irrigation management across the cotton and grain crops industry.

	• Improved information access from the links that are provided with the online version of WATERpak as readers can quickly click on the links to access other online information sources. • Provision of the latest research and best management practice information on irrigation management for cotton and grains industries. • Enhanced grower capacity to make water use efficient decisions. • A source of information for growers seeking myBMP certification thus contributing to the adoption of cotton industry best management practices. • Some recommendations from the project for future considerations were: o A future addition should include a chapter on bores, o While the chapter on Centre Pivot and Lateral Move (CPLM) irrigation systems was updated, there is potential for a substantial update in the future.
Impacts	• Increased water use efficiency in the cotton and grain cropping farms. • Enhanced industry image/social licence support for both cotton and grain growers. • Potential reduced profit losses from improved on-farm decisions such as informed management practices on water use planning, more effective fertigation practices, more efficient water storage and reduced incidence of waterlogging related diseases (David Wigginton pers. comm., 2017). • Contribution to catchment scale water quality improvements based on information from Section 6: Catchment scale impacts. • Increased industry extension and decision-making capacity.

Table 4: Logical Framework for Project DAN1305

DAN1305: Updating and Expanding WEEDpak in Support of the Cotton Industry and myBMP	
Project details	Organisation: NSW Department of Primary Industries Period: July 2012 to October 2015 Principal Investigator: Graham Charles
Rationale	WEEDpak is a collaborative document which was first written in 2001/2002 and released in hard-copy in 2002.It was released as a source of information for the cotton industry. It covered a wide range of weed issues, weed identification material, guidelines for developing an Integrated Weed Management (IWM) approach for cotton, and extensive research findings on the management of specific weeds that are hard to control. WEEDpak information was also available via the Cottoninfo website and was the most frequently sought after information on the website. However, WEEDpak information included in the former IWM approach was now out-of-date and needed updating with the most recent research and current best management practices in the interest of its continued effectiveness.
Objectives	1. To update the guidelines for Integrated Weed Management in the Roundup Ready Flex system. 2. To update information on key weed questions in MyBMP. 3. To provide more and better information on the potential for damage issues from herbicides used in other parts of the farming system. 4. To provide an improved, more user-friendly and more robust weed control threshold for cotton.
Activities and Outputs	• Undertook field and glasshouse experiments to achieve the project's objectives. • Herbicide field experiments were undertaken at various crop growth stages at the ACRI in Narrabri. • The project increased the number of weeds covered in WEEDpak's Weed Identification Guide from 102 to 200 weeds. The newly added weeds were those commonly found in cotton farming systems and areas surrounding cotton. • Grass weeds formed the majority of new additions to WEEDpak; grass weed coverage increased from 8 to 43 species; there was also a significant increase in coverage of water weeds. • The update included an additional 17 herbicides to the initial 18 in the Herbicide Damage Information Guide. • The following sections of WEEDpak were updated and/expanded: o B2. Managing Weeds in Cotton,

	○ B3. Integrated Weed Management (IWM): Guidelines for Australian Cotton Production, ○ C2. Managing Herbicide Resistance in Cotton, ○ C3. Herbicide Resistance and the Crop Management Plan, ○ D3. SPRAYpak/Spray Application, ○ F2. Farm Hygiene in Integrated Weed Management, ○ F3. Managing Weeds on Roads, Channels and Water Storages, ○ F4. Controlling Volunteer Cotton, ○ F5. Plant Protection Interactions with Weeds, ○ H3. Managing Nutgrass in Cotton, ○ H4. Managing Polymeria (Take-all) in Cotton, and ○ H10. Managing Feathertop Rhodes Grass in Cotton was added to the guide. • The updated 12 WEEDpak sections were made available online and via the COTTONpak CD. • Sections on the Best Management Guide (G) and the Herbicide and Formulation List (D2), were not updated but recommended for removal from WEEDpak as more current information was available from other sources such as the Managing Problems Weeds section in WEEDpak and in the Australian Cotton Production Manual. • Some recommendations were included for future studies on herbicide combination for control of volunteer cotton. • The project provided the Weed Identification Guide to the Sydney Herbarium and other individuals on request. • The following articles were published in peer-reviewed journals and industry's best management guides: ○ Guest, A., Maas, S., Taylor, I., Werth, J., Thornby, D. and Charles, G. (2014). Herbicide resistance in Australian cotton farming systems, in "*Cotton Pest management Guide 2014-15*", Ed. Maas, S., p. 85-87. ○ Maas, S., Werth, J., Thornby, D. and Charles, G. (2014). Weed management tactics for Australian cotton, in "*Cotton Pest management Guide 2014-15*", Ed. Maas, S., p. 92-95. ○ Monsanto Australia Ltd, S., Charles, G. and Leven, T. (2014). Roundup Ready Flex technology, in "*Cotton Pest management Guide 2014-15*", Ed. Maas, S., p. 99-101. ○ Werth J, Boucher, L, Thornby D, Walker S, Charles G (2014) Changes in weed species since the introduction of glyphosate-resistant cotton. *Crop & Pasture Science*, 64: 791-798. ○ Werth, J., Thornby, D. and Charles, G. (2014). Don't let the (herbicide resistance) cat out of the bag: US lessons, *The Australian Cottongrower*, 35 (5): 16-18. • Research findings were also shared with industry stakeholders and researchers via meetings, conference presentations, and internet publications.
Outcomes	• Enhanced industry knowledge about best practice management for weeds. • Contribution to future industry research direction from the project's recommendations. • Contributed to industry practice change to better manage cotton-related weeds. • Provided information (catalogued photographs) for use in a future Weed Identification application (WEED ID APP). • A new PhD research project at the University of New England was formulated and informed by the current project.
Impacts	• Contribution to improved cotton yields due to lower presence of weeds on-farm. • Contribution to improved cotton lint quality (from reduced competition from weeds for water, light and nutrients and from grass contamination). • Contribution to reduced rate of weed species shift. • Contribution to reduced future weed management costs. • Increased scientific research and industry capacity.

Table 5: Logical Framework for Project RRR1402

RRR1402: myBMP Lead Certification	
Project Details	Organisation: Roth Rural and Regional Pty Ltd Period: December 2013 to June 2015 Principal Investigator: Guy Roth
Rationale	There were an estimated 10 people who were trained in undertaking myBMP audits, however, only one person was still available to do audits by the end of year 2013. This was despite an increasing demand for certification audits from the cotton industry. There was, therefore, a need to train more auditors to provide myBMP certification while maintaining a consistent, robust and credible audit system for myBMP audits.
Objectives	1. To lead the myBMP audit function, including the provision of amendments and improvements to the myBMP audit function. 2. To lead the team of auditors to achieve a professional approach to auditing achieving and maintaining auditors' familiarity with myBMP. 3. To assist in the training, mentoring and scrutineering of auditors. 4. Assist in tracking practice change in the field as observed in myBMP Auditing. 5. To adjudicate disputes and propose action plans.
Activities and Outputs	• Facilitated the implementation of the myBMP audit certification system to keep up with industry demand. • Undertook pilot farm audits in Queensland and New South Wales to inform the development of better procedures, policies and systems. • Five myBMP auditors were trained in auditing farms for myBMP compliance. • Held an additional training for two people to match the skills and needs as myBMP auditors. The lead auditor accompanied the trainee auditors on farm audits and assisted them in writing up a report. • Held annual face to face meetings and six-monthly teleconferences with auditors and the myBMP General Manager and office staff. • The online audit drafting was found to be time-consuming (taking 4 days) and growers wished to get the audit results before the auditor leaves their farm; thus, it was recommended that some modifications were required. • The audit process was found to take a long time which led to higher costs, so it was recommended that this be taken into consideration by an already ongoing myBMP review. This recommendation was implemented in project INNOV229 where mobile auditing capability was developed. • Bunding in the petrochemical module was identified as one of the main barriers to certification, and greater clarity was recommended. • Reviewed the 24 Audit Office and Standard Operating Documents to ensure currency and relevancy. • Developed a new checklist for growers that can be used just prior to the audit visit. • Established a formal process to manage disputes.
Outcomes	• Increased the capacity of industry to undertake credible and robust myBMP audits of a grower's farm. • Contributed to a more efficient auditing process (reduced from 4 days to 1 day). On average this is a cost saving of $3,900 per audit, considering that the average daily fee of a professional auditor is $1,300 (Guy Roth, pers. comm., 2017). In the first 6 months of 2017 13 audits had been undertaken (Nicole Scott, pers. comm., 2017). There is an evident increase in the number of audits undertaken per year and it is likely that at least another 13 will be undertaken in 2017 alone (Rick Kowitz, pers. comm., 2017). • Contributed to changes in farm practices such as improved workplace health and safety, successful crop protection, productive resource efficiencies, responsible landscape management and better management of petrochemicals and on-the-farm natural resources. • Contributed to the increase in the number of myBMP registered and accredited farms from 70 in 2014 to 146 by July 2017, that is a 108% increase in less than 4 years (Nicole Scott, pers. comm., 2017). • Contributed to the increase in the number of cotton bales produced from myBMP accredited farms (from 15,000 bales in 2013 to 65,000 bales by 2015).

	• Contributed to increased access to premium global markets including the Better Cotton (BCI) Initiative for Australian growers.
Impacts	• Strengthened the cotton industry's social licence to operate as more farms are adopting sustainable farming practices. • Potential reduction in off-farm negative impacts from better on-farm practices. • Improved the industry capacity to undertake cost-effective audits and support certification processes. • Contribution to increased access to premium prices for Australian grown cotton where farms are myBMP and BCI certified. • Less exposure to risk and potential consequences by growers to Workplace Health and Safety, agricultural chemistry and other statutory regulations.

Table 6: Logical Framework for Project RRR1402

INNOV229: Sustainable Australian Cotton Production Supplying International Markets	
Project details	Organisation: Cotton Australia Limited Period: April 2014 to March 2016 Principal Investigator: Rick Kowitz
Rationale	Consumers are increasingly demanding ethical products that are produced in a sustainable manner. Consequently, large international retailers are increasingly adopting sustainably produced cotton for the production process. The myBMP program provides an opportunity for Australian cotton growers to change their on-farm practices to meet international sustainability market criteria and gain access to premium prices for their cotton. There was a need to update and improve the myBMP website (from its 2010 version) and develop processes through which growers could demonstrate compliance with international sustainability indicators and environmental Key Performance Indicators (KPIs). The project sought to align myBMP with international sustainable cotton marketing initiatives such as the BCI. myBMP certified growers could then gain access to the "Better Cotton Initiative" and sell their cotton at premium prices.
Objectives	1. To modernise and update the myBMP program. 2. To develop processes and functionality to report and demonstrate improvement against defined sustainability indicators and international environmental KPIs. 3. To increase the number of myBMP certified Australian cotton growers. 4. To involve an additional 40 cotton growers to trial the innovative natural resource management (NRM) practices on 40,000 hectares, in addition to the 300 growers who manage 150,000 ha already involved in the program.
Activities and Outputs	• A project steering committee was established to provide oversight and guidance to the project manager. • A comprehensive review and upgrade was undertaken for all material in the myBMP program. • Best management checklist items now include the latest research findings. The checklist was also optimised to make it more appealing to farmers while maintaining the same rigour and quality required by the cotton industry. • A spatial mapping tool was developed to provide the cotton industry with the capability to monitor the uptake of best management practices and practice change at a regional scale. • The spatial mapping tool was developed to provide information on biosecurity, biotechnology, energy and input efficiency, fibre quality, human resources, work, health and safety, IPM for insects, weeds and diseases, natural assets, pesticide management, petrochemical storage and handling, soil health, and water management. • Spatial mapping can be used, for example, to identify regional vulnerability to biosecurity threats, for example the readiness of cotton growers for a pest or disease outbreak. • Developed a sustainability dashboard to measure and monitor performance and to identify strengths, weaknesses, opportunities and threats in relation to the uptake of best management practices.

	• The project engaged stakeholders to source practical feedback on the myBMP modernisation process. • "*MyBMP Matters*", a monthly digital newsletter, was developed to communicate myBMP outcomes and the progress of this project to cotton growers and industry stakeholders. • Young cotton leaders used YouTube videos and publications on the new e-newsletter "*myBMP matters*" to champion the benefits of myBMP via three case studies. • The project developed a mobile device capability for the myBMP certification audit process. • Following a benchmark process for the Better Cotton Initiative and myBMP, the project identified that there were substantial similarities between BCI standards and the Australian myBMP program (on environmental management). • The BCI and myBMP standards were thus aligned so that cotton produced according to myBMP standards are recognised as achieving BCI standards. These standards are driven by the Better Cotton Initiative which is demanded globally by companies such as Ikea, Nike, H&M, Levis, Adidas, and Walmart, among others. • A formal partnership with BCI was signed on behalf of the Australian cotton industry on 11th June 2014. • Also in 2014 the Australian cotton industry entered into a partnership with the US cotton industry called Cotton LEADS ™. This is a program that is committed to responsible cotton production and is founded on core principles that are consistent with sustainability and the use of best practices and traceability in the supply chain. • A total of 102 additional cotton farmers used myBMP to trial innovative farming practices across 50,500 hectares as a result of the project. • The project established a working relationship between myBMP program and the Sustainability Working Group who then provided valuable feedback on project deliverables and developed myBMP targets for 2019, 2024 and 2029 in consultation with industry partners.
Outcomes	• The project made improvements to myBMP, which is the cotton industry's web-based management practice platform. • Contributed to an increase in myBMP certified farms from less than 70 to 97 farms between 2014 and 2016. • Secured industry access to the BCI and premium pricing for Australian grown cotton. • Key contribution to the development and integration of sustainability indicators which has enabled the Australian cotton industry to expand into the growing demand for sustainable cotton by international retailers such as Adidas, Ikea, Nike, H&M, Levi Strauss & Co, Tommy Hilfiger and Kathmandu. • Secured a partnership with the US cotton industry's Cotton LEADS ™ as a commitment to supply and use responsibly-produced cotton. • More accurate and cost-effective certification process as auditors use mobile devices. • Contributed to the increase in the number of myBMP registered and accredited farms from 70 in 2014 to 146 by July 2017, that is a 108% increase in less than 4 years (Nicole Scott, pers. comm., 2017). • Contributed to the increase in the number of cotton bales produced from myBMP accredited farms (from 15,000 bales in 2013 to 65,000 bales by 2015). • Significantly increased myBMP registered farms to 970 farms (or 80% of the industry) by July 2017. As of July 2017, 162 farms were registered at level 1 and 2, and another 159 farms were registered at level 1 only.
Impacts	• Increased cotton industry income from access to premium pricing due to accreditation by international marketing initiatives for sustainable and ethical cotton. • Reduced negative impacts on the environment from on-farm cotton industry practices. • Maintenance and enhancement of the industry social licence to produce cotton. • Cost savings from an improved and efficient certification process.

	• Cost savings and/or increased income from use of best practices by cotton growers who are myBMP registered.

Table 7: Logical Framework for Project CRDC1428

CRDC1428: Consultancy Agreement: Review of the Content in and Between the myBMP Modules	
Project details	Organisation: Rachel Holloway (Consultant) Period: June 2014 to September 2014 Principal Investigator: Rachel Holloway
Rationale	Over the last ten years, myBMP had evolved from a paper-based risk assessment program to a comprehensive on-line farm management tool. There had also been some changes including the addition of new myBMP modules to ensure cotton growers had a comprehensive best practice program. There was, therefore, a need to undertake a review of myBMP to ensure that the myBMP modules were delivering consistency across the 11 modules, and that modules were presented in a way that was easy for growers to understand and implement.
Objectives	1. To review the content and consistency of the 11 myBMP modules. 2. To review the myBMP practices to ensure that the practices are practical for cotton growers to implement. 3. To provide comment on the current review of the Natural Asset module.
Activities and Outputs	• After the pilot study and initial discussions with the myBMP module leads, it became clear that not all 11 modules could be reviewed and thus more attention was given to modules that focused on level 1 requirements (legal requirements). • A total of 10 myBMP modules were assessed and some feedback to module leads provided. These 10 myBMP modules were: (i) Biosecurity, (ii) Biotechnology, (iii) Energy, (iv) Human Resources (HR), (v) Workplace Health and Safety (WHS), (vi) Insects, Diseases and Weeds, (vii) Natural Assets, Pesticide Management, (viii) Petrochemicals, (ix) Soil, and (x) Water. • There were four modules that received an extensive review, these were the WHS, Biosecurity, Natural Assets, and Water, and were then deemed ready for the myBMP update. • Biosecurity was reviewed and re-rewritten and it was recommended that a process be put in place to ensure feedback on the use of the module. • WHS was reviewed and re-rewritten and it was recommended that a process be put in place to ensure feedback on the use of the module. • A review and some minor changes were made to the Water module. Several areas were identified as requiring changes for consistency and resources updating, but, due to time constraints, it was recommended that another review be undertaken at a later date. • A review of these Biosecurity, WHS and Natural Assets modules led to a reduction of the grower checklist items by 47% or 50% for each module. • Contact was made with the Biotechnology lead and it was recommended that the module will need a review in light of the changes to Bollgard 3. • Energy and Fibre quality modules were not reviewed; however, it was recommended that the modules needed a review for consistency and resources, especially against other related modules. • The HR module was reviewed and discussed with the module lead, it was recommended that the module be further updated for consistency. • Contact was made with the Insects, Diseases and Weeds module lead; after discussions with the module lead it was recommended that the module needed a review for consistency, resources and against other related modules. • Initial discussions were held with the Pesticide Management module lead and these discussions indicated that the module was in a need of a complete re-write. It was also recommended that the module needed a review for consistency, resources, legislation and against other modules.

	• The Petrochemicals module was reviewed and some comments were made on the working document. A need for further review for resources and legal requirements (e.g. bunding diesel) was identified. • The Soil Health module was not reviewed as the module lead indicated that SOILpak needed updating, there were also some information gaps that needed to be reviewed for consistency, resources and against other modules where there were references to soil (e.g. Water, Natural Assets, Insects, Weeds, and Biosecurity modules). • The project undertook piloting of myBMP on seven farms in Goondiwindi; only one grower was able to complete level 1 to 3. • The review showed that growers did not understand some of the myBMP practices and some of the resource information was out of date. • Growers provided some comments on self-assessment.
Outcomes	• Provision of up-to-date information resources for cotton growers and extension officers. • Potentially improved grower compliance with current legal requirements from easier access to current resources. • Potentially reduced operational risk to farmers by implementing the most current best management practices. • Potential time saving from up to 50% reduction of grower checklist items for WHS, Biosecurity and Natural assets. • Contribution to improvements in pesticides and petrochemical management.
Impacts	• Contribution to increased adoption of best management practices in the cotton industry. myBMP registered farms have increased from 70 in 2014 to 146 by July 2017, this is a 108% increase in less than 4 years (Nicole Scott, pers. comm., 2017). • Potentially enhanced management of natural assets for better environmental and production outcomes. • Potentially improved water quality from improved management of chemical on-farm. • Potentially cost savings from work-related employee compensations. • Contribution to enhanced protection of farms from introduction and spread of pests and weeds.

4. Cluster Investment

The Investment

The following tables show the annual investment by project for both CRDC (Table 8) and for researchers and any other investors (Table 9). Table 10 provides the total investment by year from both sources.

Table 8: Investment by CRDC for Years Ending June 2012 to June 2016 (nominal $)

Project ID	2012	2013	2014	2015	2016	Total
CSP1201	183,679	192,149	200,405	0	0	**576,233**
DWC1201	53,322	53,322	0	0	0	**106,643**
DAN1305	0	339,253	336,284	351,301	0	**1,026,838**
RRR1402	0	0	20,000	45,550	0	**65,550**
INNOV229	0	0	128,000	128,000	128,000	**384,000**
CRDC1428	0	0	25,920	0	0	**25,920**
Totals	**237,001**	**584,724**	**710,609**	**524,851**	**128,000**	**2,185,184**

Table 9: Investment by Researchers and Others for Years Ending June 2012 to June 2016 (nominal $)

Project ID	2012	2013	2014	2015	2016	Total
CSP1201	153,542	157,380	161,315	0	0	**472,237**
DWC1201	64,759	2,454	0	0	0	**67,213**
DAN1305	0	514,854	548,931	585,546	0	**1,649,331**
RRR1402	0	0	5,046	11,492	0	**16,538**
INNOV229	0	0	236,945	236,945	236,945	**710,835**
CRDC1428	0	0	0	0	0	**0**
Totals	**218,301**	**674,688**	**952,237**	**833,983**	**236,945**	**2,916,154**

Table 10: Total Annual Investment by Year (nominal $)

Year ending June	CRDC	Researchers and Others	Total
2012	237,001	218,301	455,302
2013	584,724	674,688	1,259,412
2014	710,609	952,237	1,662,846
2015	524,851	833,983	1,358,834
2016	128,000	236,945	364,945
Total	**2,185,184**	**2,916,154**	**5,101,338**

Program Management and Extension Costs

For CRDC investment, the cost of managing the CRDC funding was added to the CRDC contribution via a management cost multiplier (1.1325); this was estimated based on the average reported share of ‘employee benefits’ & ‘supplier’ expenses in total CRDC expenditure for 2014/15 and 2015/16 (CRDC, 2016). No additional costs of extension were included as most projects were either largely extension-focussed or already included an extension component.

5. Impacts

The principal potential impacts for the myBMP project cluster were assembled from the logical frameworks developed for the individual projects. In addition, several general impacts applicable to all six projects were identified. Table 11 summarises the key potential impacts identified and signifies whether a contribution was made to each potential impact by each of the six projects.

Table 11: Contribution by Project to Principal myBMP Cluster Impacts

Project Code	Enhanced Market Returns and Market Positioning	Input Cost Savings and/or Increased Productivity	Increased Water Use Efficiency	Maintenance of Social Licence	Reduced Cost of Undertaking myBMP Audits	Increased Scientific Research and Industry Capacity	Reduced Off-farm Negative Impacts	Regional Community Income Spillovers
CSP1201	✓	✓		✓		✓		✓
DWC1201		✓	✓	✓		✓	✓	✓
DAN1305	✓	✓		✓		✓		✓
RRR1402	✓	✓		✓	✓		✓	✓
INNOV229		✓	✓	✓	✓	✓	✓	✓
CRDC1428	✓	✓	✓	✓			✓	✓

From Table 11, the potential impacts were then condensed and described in a triple bottom line context. Table 12 provides a summary of the principal types of impacts associated with economic, environmental and social categories.

Table 12: Triple Bottom Line Categories of Principal Impacts from the myBMP Cluster Investment

Economic	• Increased access to premium pricing. • Input cost savings and/or increased productivity from adoption of best management practice. • Contribution to enhanced water use efficiency. • Reduced risk of losing part of social licence to operate. • Reduced costs of myBMP auditing for cotton farmers.
Environmental	• Improved water quality at a catchment level from better use of water and chemicals.
Social	• Increased scientific research capacity. • Regional community income spillovers.

Public versus Private Benefits

Most of the identified benefits in this evaluation are cotton industry related and therefore are considered private benefits. However, there are important benefits that are accruing to the public, including some environmental and social benefits. Environmental benefits include contribution to reduced negative off-farm impacts, while social benefits include contribution to incomes in the community as a result of increased/maintained cotton industry incomes as well as the enhanced research capacity.

Distribution of Impacts along the Supply Chain

While there are some notable impacts to the grains industry from project DWC1201, most of the impacts (economic, environmental and social) from all six myBMP projects are concentrated at the cotton enterprise and the associated regional cotton communities. Some of the financial benefits and costs at the farm level will likely be passed along the input and output supply chains in proportion to the elasticities of supply and demand at different stages along the chain.

Impacts on other Industries
Some project outputs (e.g. water efficiency) are not necessarily specific to the cotton industry and are applicable to the grain crops industry. Also, many of the impacts may have spillover effects on farm enterprises other than cotton (e.g. improved weeds management).

Impacts Overseas
Overseas benefits are not expected to be significant, as most research outputs apply to Australian cotton production environments. However, some multinational corporations who face increased consumer demand for ethical grown cotton would benefit from an increased supply of sustainably produced cotton that is accredited by the Better Cotton Initiative and/or Cotton LEADS ™.

Match with National Priorities
The Australian Government's Science and Research Priorities and Rural Research, Development and Extension (RD&E) priorities are reproduced in Table 13. The cluster contributes primarily to Rural RD&E Priorities 2, 3 and 4, and to Science and Research Priorities 1 and 2.

Table 13: 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 and Resources 6. Manufacturing 7. Environmental Change 8. Health

Sources: DAWR (2015) and OCS (2016)

6. 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 a high degree of 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.

Five of the impacts summarised in Table 11 were valued in this analysis. The valued impacts were:

- Access to premium prices for Australian grown cotton
- Input cost savings and/or increased productivity
- Increased water use efficiency
- Contribution to maintenance of social licence to grow cotton
- Reduced cost of undertaking myBMP audits

All six projects in the population were identified as contributing to one or more of the five impacts valued in this analysis.

Impacts Not Valued
Three impacts identified in Table 11 were not valued, these were:

- Increased scientific research & industry capacity
- Reduced off-farm negative impacts
- Regional spillovers

Impacts related to increased scientific research & industry capacity were not valued in the current analysis due to difficulties in quantifying the various specific ways in which the capacities developed are being utilised for research and industry purposes. Improvements in the management of chemicals on-farm such as better weeds and pest management, fertiliser applications and bunding will lead to reduced negative impact on water quality off-farm. For example, potential environmental benefits include healthier waterways that better support the ecosystem and water-related amenity services. While these benefits are important, limitations in data availability make it difficult to extract specific benefits emanating from myBMP projects. Another impact that was not valued is the regional spillovers, this impact was not valued due to limited data availability and difficulties in isolating the specific monetary impact from the broader social impacts.

Valuation of Benefit 1: Enhanced Market Returns and Market Positioning
All projects in this cluster have contributed to Benefit 1 through availability and/or improved ease of access to information/technologies to support adoption of best management practices by cotton growers and consultants. As a result, more farmers have been registered and audited for myBMP accreditation. Consequently, there has been an increase in the number of farms producing BCI certified cotton and thus attracting premium prices for their cotton bales. A conservative estimate of $3 per bale has been used in the valuation as the likely premium (Nicole Scott, pers. comm., 2017). The conservative estimate takes into consideration the possibility of auditing costs to retain BCI accreditation over the period for which the benefit is assumed to be delivered. Specific assumptions for valuing this benefit are provided in Table 14.

Valuation of Benefit 2: Input Cost Savings and/or Increased Productivity
In addition to access to premium pricing in Benefit 1, there are some benefits to growers who adopt best management practices but are yet to attain the myBMP accreditation or BCI certification level. An estimated 619 additional growers were using myBMP practices by July 2017, thus the total number of myBMP registered growers has increased to 970 growers (Nicole Scott, pers. comm., 2017). Improvements in information, accessibility and functionality to the CottASSIT tools and other myBMP documents will contribute to strategic decision making by both growers and consultants. Overall, this indicates that more growers have the opportunity to adopt best management practices which include better management of weeds, pests, water use, employees, and other inputs to increase productivity and efficiency.

A generalised approach has been utilised in estimating this benefit due to a lack of specific information on the impacts of adopting the various best management practices. Some benefits may accrue from a direct input cost reduction but others (e.g. a yield increase) may accrue from increases in input costs. In the latter case, the productivity gain can be translated into an equivalent net reduction to the cost of production (Chudleigh, 1991). The rationale for using input cost reduction to estimate the value of productivity gains is that where growers are able to produce more with an unchanged or a relatively lower increase in

the cost of inputs (compared to gains in productivity) then the net productivity gains can be measured as a fall in the cost of production.

All six projects were assessed as contributing to input cost savings and/or increased productivity. The assumptions used to estimate the economic value of this impact are based on a conservative estimate of the proportion of industry experiencing the benefit, the average annual cotton growing area, and an estimated lower production cost per unit of cotton that might be affected. The specific assumptions used in valuing this impact are provided in Table 14.

Valuation of Benefit 3: Increased Water Use Efficiency

Cotton growing is a relatively water intensive undertaking. Water management is one of the key modules in myBMP and this module was reviewed and updated in Project CRDC1428. Project DWC1201 also focused on updating WaterPAK and integrating it with myBMP. By accessing myBMP tools and information, growers are exposed to current best management practice with regards to efficient water use. It is assumed that this cluster has contributed to additional improvements in uptake of best management practices from the updated WaterPAK and myBMP on water and irrigation research. The increase in adoption of more efficient on-farm water practices is expected to be driven by grower economic benefits and improved ease of access to myBMP website and support resources.

Irrigation Water Use Index (IWUI) and Gross Production Water Use Index (GPWUI) are two of the key indices used to measure water use efficiency (WUE). IWUI relates cotton yield to irrigation water used whereas GPWUI relates yield to total water used to grow the crop, including irrigation water applied, rainfall and stored soil moisture. The latter is more complex to calculate and it requires extensive data which is not always available. In comparison, applied irrigation water is available from the Australian Bureau of Statistics estimates on water use in Australian farms (ABS 2016b). For this reason, the current analysis used increased IWUI as a means for measuring increases in WUE, with a conservative IWUI estimate to account for annual variability in the volume of irrigation water applied relative to other water sources.

The valued water use efficiency gains in this cluster are those achieved via on-farm practice such as improved irrigation scheduling regimes and monitoring capabilities. Irrigation scheduling involves applying the right amount of water, in the right place at the right time in order to maximise production and improve water use efficiency. Soil moisture monitoring assists growers to better schedule irrigation at specific locations in a field to avoid wastages or undersupply. Specific details of the assumptions for the estimated benefit are provided in Table 14.

Valuation of Benefit 4: Maintenance of Social Licence

The right to farm (a social licence) has become contentious, not only in Australia, but elsewhere around the world. This applies to both plants and animals. In the case of cotton, the main issues have been raised by environmental groups and have been related to genetic modification, the use of water resources, and the use of chemicals in cotton farms.

All six projects in the myBMP cluster have been assessed as contributing to the maintenance of social licence impact. The assumptions used to value this impact have been derived from a series of assumptions related to:

- A conservative estimate of the area of cotton that may be affected.
- The value of the lost area of cotton.
- The reduced risk of a loss of social licence due to investment in the myBMP cluster.

Specific details of the assumptions for the estimated benefit are provided in Table 14.

Valuation of Benefit 5: Reduced Cost of Undertaking myBMP Audits

Prior to investment in this cluster, the myBMP audit process took four days to complete. In this cluster, a more efficient auditing process was recommended in project RRR1402 and later developed in project INNOV229. Consequently, the auditing process now takes a day compared to four days prior to investments in this cluster. The 75% reduction in auditing costs represents significant savings to individual farmers. The myBMP accreditation is granted for a five-year period, and growers must remain accredited to opt in to BCI annually. In addition, a random audit program is conducted each year with 5% of the myBMP certified businesses being audited (Nicole Scott, pers. comm., 2017). Specific assumptions for valuing this benefit are provided in Table 14.

Counterfactual

Without investment in this group of myBMP projects, it is likely that many growers would have continued to use relatively out-of-date information and the updating process would have been much slower, less coordinated and there would have been limited impact especially with regards to access to premium pricing, lower auditing costs and maintenance of social licence to operate. Benefits assigned to the investment are estimated based on the additional number of farms or additional area assumed to be influenced by the cluster investment, compared to what may have occurred without the investment.

Summary of Assumptions

A summary of the key assumptions made for valuation of the impacts is shown in Table 14.

Table 14: Summary of Assumptions

Variable	Assumption	Source
Benefit 1: Enhanced Market Returns and Market Positioning		
Estimate of number of growers with BCI certification	97	Kay and Kowitz (2016)
Additional growers assumed to be involved with BCI due to the myBMP project investments	45, over period 2015-2019	Agtrans Research conservative estimate based on information from Kay and Kowitz (2016) and Nicole Scott pers. comm. (2017)
Total average cotton output	3.488 million bales (average past five years)	Cotton Australia (2017a)
Number of cotton farms	1,200	Cotton Australia (2017b)
Average number of bales per farm	2,907	3.488 million/1200
Increase in price due to BCI certification	$3 per bale	Nicole Scott pers. comm. (2017) and Cotton Australia (2017c)
Average revenue gain per farm	$8,721	2,907 bales x $3 per bale
Benefit 2: Input Cost Savings and/or Increased Productivity		
Assumed annual average cotton area	380,000 ha	5-year average area harvested 2012 to 2016), ABARES (2016)
Estimated average input costs	$2,955.75	Estimated average total variable cost for NSW regions less costs of irrigation (NSW DPI, 2015).

Input cost savings and/or productivity gain	0.5%	Agtrans Research
Proportion of industry gaining benefits from input cost savings and/or productivity gain	25%	Agtrans Research
Probability of impact from input cost savings/increased productivity	75%	Agtrans Research
Year of first benefit	2015	Agtrans Research
Number of years to maximum adoption	5 years	Agtrans Research
Benefit 3: Increased Water Use Efficiency		
Base IWUI	1.7 bales/ML	Based on average for years 2006 to 2011 for farmers located in the Hillston to Emerald area and the Condamine to Lower Balonne areas (Montgomery and Wigginton, 2013)
Value of additional output	$350/bale	Conservative estimate based on Cotton Australia (2016d) and allowing for quality discounts
Cost of harvesting and transporting additional output	$30/bale	Conservative estimate based on Boyce (2015)
Industry applicable area – irrigated cotton	306,684 ha/annum	ABS (2016a), average of years 2011, 2013, 2014 & 2015
Average application rate	7.5 ML/ha	ABS (2016b)
Estimated total water usage by irrigated cotton	2,300,130 ML/annum	306,684 ha/annum* 7.5 ML/ha
Average WUE increase without myBMP	3%	Agtrans Research (2017)
Average WUE increase with myBMP	4.5%	Agtrans Research
Attribution to cluster	25%	Agtrans Research
Ongoing practice change	$25/ha	Agtrans Research (2017)
Maximum additional adoption	25% of irrigation by volume	Agtrans Research (2017)
Year of first adoption	2015	Agtrans Research (2017), this allows for completion of the relevant projects and some time for information dissemination.
Number of years to maximum adoption	5 years	Agtrans Research
Benefit 4: Maintenance of Social Licence		
Assumed annual average cotton area	380,000 ha	5-year average area harvested 2012 to 2016), ABARES (2016)
Margin of irrigated cotton over irrigated wheat (assumed next best crop)	$1,500 per ha	Derived from Cotton and Wheat Gross Margin Analysis, Cotton Seed Distributors, March 2008
Maximum proportion of industry assumed lost to cotton	20%	Agtrans Research
Probability of loss occurring without project cluster	10%	Agtrans Research

Probability of loss occurring with project cluster	8%	Agtrans Research
Year loss first avoided due to cluster	2019	Agtrans Research
Number of years to reach maximum loss	5	Agtrans Research
Attribution of this benefit to the myBMP cluster versus the total benefit attributed to the myBMP and Sustainability clusters combined	75%	Agtrans Research
Benefit 5: Reduced Cost of Undertaking myBMP Audits		
Average audit cost per day	$1,300	Guy Roth pers. comm. (2017)
Number of days to complete the audit without current cluster	4	Guy Roth pers. comm. (2017)
Number of days to complete the audit with current cluster	1	Guy Roth pers. comm. (2017)
Cost savings per audit	$3,900	Based on audit taking 1 day compared to 4 days at an average cos t of $1,300 per day (Guy Roth pers. comm., 2017)
Number of audits per year	30	Agtrans Research after communications with Rick Kowitz and Nicole Scott. This is a conservative estimate covering all audits undertaken per year. The estimate includes the initial farm audit, the subsequent audit at the end of the 5 year period to remain certified and the random annual audits of 5% of the myBMP certified farms.
First year of benefits	2016	Agtrans Research, based on technology delivery

7. Results

All past costs and benefits were expressed in 2016/17 dollar terms using the Implicit Price Deflator for GDP (ABS, 2016c). All benefits after 2016/17 were expressed in 2016/17 dollar terms. All costs and benefits were discounted to 2016/17 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 investment period plus 30 years from the last year of investment (2015/16) to the final year of benefits assumed.

Investment Criteria

Tables 15 and 16 show the investment criteria estimated for different periods of benefits for both the total investment and for the CRDC investment respectively. The present value of benefits (PVB) attributable to CRDC investment only, shown in Table 16, has been estimated by multiplying the total PVB ($58.15 million) by the CRDC proportion of real investment (42.9%).

Table 15: Investment Criteria for Total Investment in the Six Projects
(Discount rate 5%, Re-investment rate 5%)

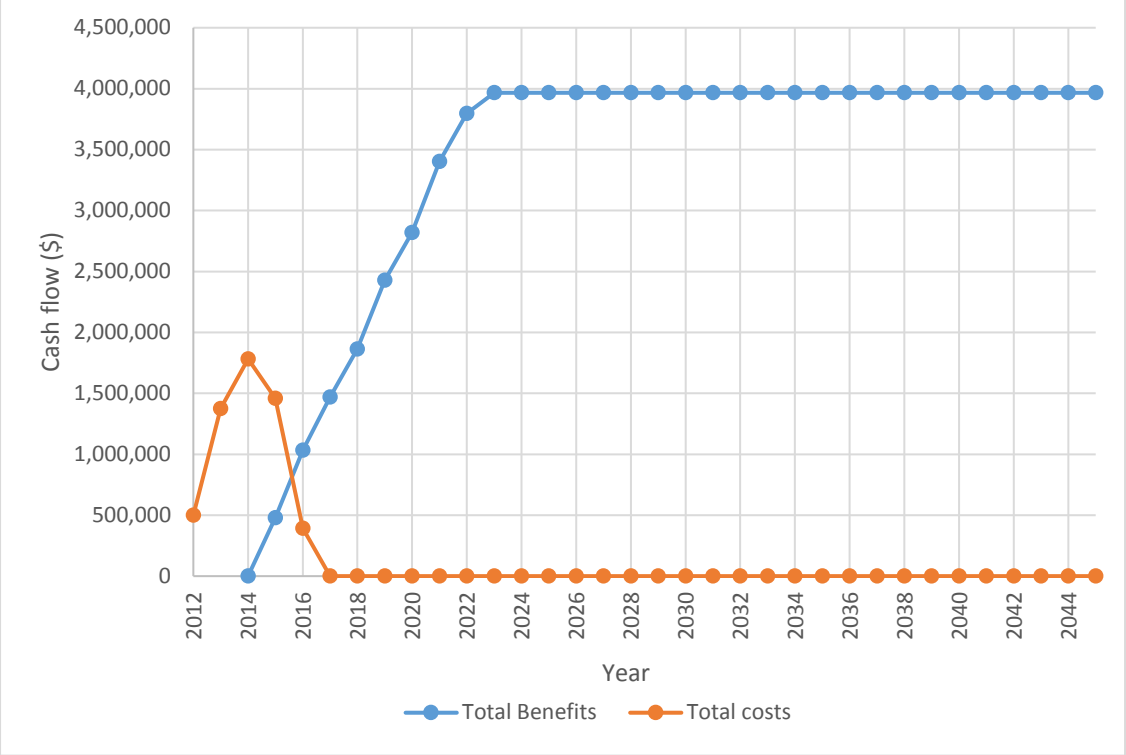
Investment criteria	Number of years from year of last investment						
	0	5	10	15	20	25	30
Present value of benefits ($m)	1.61	12.30	26.29	37.36	46.03	52.83	58.15
Present value of costs ($m)	6.39	6.39	6.39	6.39	6.39	6.39	6.39
Net present value ($m)	-4.78	5.90	19.90	30.97	39.64	46.43	51.76
Benefit-cost ratio	0.25	1.92	4.11	5.84	7.20	8.26	9.10
Internal rate of return (IRR) (%)	negative	20.44	29.35	30.84	31.18	31.26	31.28
Modified IRR (%)	negative	13.92	17.18	16.04	14.66	13.48	12.52

Table 16: Investment Criteria for CRDC Investment in the Six Projects
(Discount rate 5%, Reinvestment rate 5%)

Investment criteria	Number of years from year of last investment						
	0	5	10	15	20	25	30
Present value of benefits ($m)	0.74	5.65	12.07	17.15	21.14	24.26	26.70
Present value of costs ($m)	2.95	2.95	2.95	2.95	2.95	2.95	2.95
Net present value ($m)	-2.21	2.70	9.12	14.20	18.19	21.31	23.75
Benefit-cost ratio	0.25	1.91	4.09	5.81	7.16	8.22	9.05
Internal rate of return (IRR) (%)	negative	19.94	28.78	30.28	30.62	30.71	30.73
Modified IRR (%)	negative	13.76	17.05	15.93	14.58	13.41	12.46

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

Figure 2: Annual Cash Flow of Undiscounted Total Benefits and Total R&D Costs in the Project Cluster



Sources of Benefits

Given the assumptions made, the contribution of each of the individual benefits to the Total Present Value of Benefits (PVB) are shown in Table 17.

Table 17: Contribution of Each of the Five Benefits to the PVB

Source of myBMP Benefits	Contribution to PVB ($m)	Share of Benefits (%)
Benefit 1: Enhanced Market Returns and Market Positioning	6.58	11.31
Benefit 2: Input Cost Savings and/or Increased Productivity	17.05	29.32
Benefit 3: Increased Water Use Efficiency	11.23	19.32
Benefit 4: Maintenance of Social Licence	21.28	36.59
Benefit 5: Reduced Cost of Undertaking myBMP Audits	2.01	3.46
Total PVB	58.15	100.00

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 18 presents the results. The results showed a moderate sensitivity to the discount rate.

Table 18: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	112.48	58.15	35.81
Present value of costs ($m)	5.51	6.39	7.39
Net present value ($m)	106.97	51.76	28.43
Benefit-cost ratio	20.42	9.10	4.85

Further sensitivity analyses were conducted on three other key variables. These key variables were the probability of loss of social licence, input cost savings/productivity gains and the adoption rate for WUE (Tables 19 to 21).

The largest contributor (36.59%) to the Total PVB was the risk avoidance benefit for the social licence to farm cotton. Investment criteria for various scenarios for the reduction in risk are provided in Table 19.

Table 19: Sensitivity to Change in Probability of Loss of Social Licence
(Total investment, 30 years, 5% discount rate)

Investment Criteria	Reduced Probability of Loss Occurring with Cluster Investment		
	10% reduced to 5%	Base: 10% reduced to 8%	10% reduced to 9%
Present value of benefits ($m)	90.07	58.15	47.51
Present value of costs ($m)	6.39	6.39	6.39
Net present value ($m)	83.68	51.76	41.12
Benefit-cost ratio	14.09	9.10	7.43

The second largest contributor (29.32%) to the Total PVB was the input cost savings/increased productivity. Investment criteria for various scenarios for the reduction in risk are provided in Table 20.

Table 20: Sensitivity to Change in Input Cost Savings
(Total investment, 30 years, 5% discount rate)

Investment Criteria	**Input Cost Reduction**		
	0.25%	**Base: 0.5%**	**1%**
Present value of benefits ($m)	49.63	58.15	75.20
Present value of costs ($m)	6.39	6.39	6.39
Net present value ($m)	43.23	51.76	68.81
Benefit-cost ratio	49.63	9.10	11.76

The third largest contributor (19.32%) to the Total PVB was the increased water use efficiency from irrigation practice changes in the cotton industry. Investment criteria for various scenarios for the reduction in risk are provided in Table 21.

Table 21: Sensitivity to Change in Adoption Rate for WUE
(Total investment, 30 years, 5% discount rate)

Investment Criteria	**Water Use Efficiency with Cluster Investment**		
	0.75%	**Base: 1.5%**	**3%**
Present value of benefits ($m)	48.66	58.15	77.15
Present value of costs ($m)	6.39	6.39	6.39
Net present value ($m)	42.26	51.76	70.75
Benefit-cost ratio	7.61	9.10	12.07

Confidence Ratings and other Findings

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

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 22). 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 22: Confidence in Analysis of Cluster

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

Coverage of benefits was assessed as medium-high as a range of benefits were identified and valued. While some impacts were not valued, these were subjectively assessed as being minor relative to those valued.

Confidence in assumptions was rated as medium-low. The assumptions that have been made for valuing the benefits from these investments are potentially conservative. The principal reason for this was the lack of data regarding current adoption by the cotton industry of practice changes that may have been driven by the investments and the average and range of the value to growers for making such changes. In this regard, it is suggested that CRDC further develops its capacity to monitor, report and/or assess impacts and adoption from individual or grouped project investments. This can be aided via such mechanisms as assembling feedback from growers at industry events, consultant and agronomist surveys, and specific case studies that could be included in final project reports.

8. Conclusions

myBMP is a widely used cotton industry farm and environmental management system. Thus, the current myBMP cluster investment was an important and relevant undertaking that has led to the updating of information in numerous industry best management practice guides. The investments also contributed to improved access of information by growers, researchers and consultants. Additionally, establishment of Australian cotton growers' access to premium pricing initiatives helps to support continued adoption of practices that have economic, and social and/or environmental benefits for the growers and their communities.

Funding for the six projects in the cluster totalled $6.39 million (present value terms) and produced aggregate total expected benefits of $58.15 million (present value terms). This gave a net present value of $51.76 million, a benefit-cost ratio of 9.10 to 1, an internal rate of return of 31.28% and a modified internal rate of return of 12.52%.

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