Final Report to

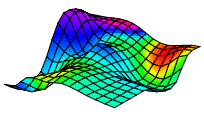
Cotton Research and Development Corporation

Cost Benefit Analyses of Randomly Selected Research

Funded by the

Cotton Research and Development Corporation

24 April 2008



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FOREWORD

The Cotton Research and Development Corporation (CRDC) engaged BDA Group to undertake a triple bottom line evaluation of their investment in three randomly selected sub-programs. This evaluation forms part of a broader examination of investment projects funded by Australian Rural Research and Development Corporations. The purpose of the evaluation was to demonstrate the range of returns that can be generated on investments made by CRDC. It was not the purpose here to assess whether or not CRDC investment in the three sub-programs has been worthwhile from either an economic, environmental or social perspective. This issue has been examined in previous studies.

This report presents the triple bottom line evaluation of CRDC's investment in the Women in Cotton network, Soils R&D and Fibre Classification.

In undertaking this study considerable support was provided by CRDC staff, and in particular Bruce Pyke and Helen Dugdale. Kate Schwager (Webteam Australia), Dr Ian Rochester (CSIRO), Dr Nilantha Hulugalle (NSW DPI), Dr Stuart Gordon (CSIRO) and Dr Geoff Naylor (CSIRO) also provided considerable background material and feedback to BDA Group. Their assistance and support is gratefully acknowledged.

David Collins
Director
BDA Group

EXECUTIVE SUMMARY

BDA Group was engaged by the Cotton Research and Development Corporation (CRDC) to complete a cost benefit analysis (CBA) of their investment in three randomly selected R&D sub-programs. The CBA considered economic, environmental and social benefits that could be attributed to the CRDC investment and provides an objective assessment of the returns that the CRDC has been able to generate for its levy payers and Australia more broadly. CBA results will also be used by the Council of Rural Research and Development Corporation Chairs to demonstrate the range of returns that has been (and might be) generated as a result of the Federal government's support of rural research and development in Australia.

Random Sub-Program 1 – WINCOTT

The CRDC has supported the Women in Cotton (WINCOTT) network since 1999. Largely conceived and driven by women involved in the cotton industry, CRDC support has enabled the establishment and growth of WINCOTT through time. There are currently some 280 official members.

Benefits from WINCOTT are largely social, rather than impacting directly on levy payers' bottom line. The main value to members from being a part of WINCOTT has been access to information on the cotton industry and business more broadly that is tailored specifically for women. Participation at field days, meetings and information seminars also provides networking opportunities for women involved in the cotton industry. Benefits have also been realised by the broader community. WINCOTT functions are typically open to all and through the many social groups with which WINCOTT members are involved it can be expected that the broader community has gained a better appreciation of the importance and operation of the cotton industry in regional areas of Australia.

Given the success of the WINCOTT network and the likelihood that membership will increase through time, the cost effectiveness of the investment was estimated to be $25 per member per year on the total investment made by CRDC. The estimated return on government funds (as part of matching contributions) was estimated at $13 per member per year.

Random Sub-Program 2 – Soils Research

Soils research has been a major component of CRDC's investment portfolio over many years. For the 2003 to 2008 Strategic Plan the focus of the research shifted to improving nutrient management and soil quality. Research completed to date has shown that the average volume of nitrogen fertiliser currently applied to cotton crops can be reduced without any significant loss in cotton yields. Main benefits include:

- ***Economic*** – cost saving from reduced fertiliser use.
- ***Environmental*** – reduced greenhouse gas emissions as lower application rates result in less nitrogen being converted to either pure nitrogen or nitrous oxide.
- ***Social*** – increased economic opportunities in regional Australia and on-going support of internationally recognised scientific and extension expertise in soils R&D.

BDA Group estimated that the CRDC investment will deliver a return to levy payers of $24m, or $26 for every dollar invested by levy payers. The return on matching funds provided by the Federal government was estimated at $10 for every dollar invested.

DISTRIBUTION OF RETURNS FROM CRDC INVESTMENT ACROSS DIFFERENT SECTORS

	Net Present Value	*Benefit Cost Ratio*	*Internal Rate of Return*
Levy Payers →	$24m	26	29%
Australia →	$8m	10	22%

Random Sub-Program 3 – Fibre Classification

CRDC has supported CSIRO in the development of new technologies to measure fibre fineness and maturity. If successful such technologies would support changes to the traditional classification system for cotton and better identify and reward cotton with superior fibre characteristics. Main benefits include:

- ***Economic*** – higher prices paid for finer (and mature) cotton and royalties earned on equipment sales.
- ***Social*** – increased economic opportunities in regional Australia and the emergence of Australia as an internationally recognised leader in the development of objective fibre measurement technologies for cotton.

BDA Group estimated that the CRDC investment will deliver an expected return to levy payers of $10m, or $12 for every dollar invested by levy payers. The return on matching funds provided by the Federal government was estimated at $6 for every dollar invested.

DISTRIBUTION OF RETURNS FROM CRDC INVESTMENT ACROSS DIFFERENT SECTORS

	Net Present Value	*Benefit Cost Ratio*	*Internal Rate of Return*
Levy Payers →	$10m	12	32%
Australia →	$5m	6	23%

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1 INTRODUCTION

The Council of Rural Research and Development Corporation Chairs (CRRDCC) is developing a framework for the evaluation of research and development investments across Australian based research and development corporations. This will enable individual research and development corporations to develop improved in-house evaluation systems as well as enabling evaluation results to be aggregated across all these corporations. The evaluation framework is based on cost benefit analysis (CBA) methods with standardised time frames, discount rates and treatment of investment risk.

There are three parts to the evaluation framework adopted by the CRRDCC. These are[1]:

1. Benefit cost analysis of randomly selected projects each year to provide an indication of the range and trends from the total RDC investment portfolio over a three year period. The chosen sample is to be statistically representative of all RDC investments to ensure that the mean of returns estimated across the sample are within 0.35 standard deviations of the population[2] mean. A pool of evaluations will be built over three years.
2. Benefit cost analysis of significant and successful projects from the RDC portfolio to demonstrate that the entire portfolio is delivering private and public benefits. This part of the framework has been called the Hero Study.
3. An analysis of two early stage collaborative projects to measure the value of "work in progress".

The Cotton Research and Development Corporation (CRDC) commissioned BDA Group to undertake the Hero Study. A final report[3] was submitted to CRDC in November 2007, and in that report it was estimated that a minimum return of $13 on every dollar invested by Australia cotton growers had been achieved. Further, it was estimated that a minimum return to Australia of $30 was achieved on every dollar of matching funds provided by the commonwealth government.

In 2008 CRDC engaged BDA Group to undertake the evaluation of the randomly selected projects. Three projects were selected and estimated returns from these projects are provided in this report.

This report is divided into four main sections. The first section provides details of how projects were selected. In the final three sections a detailed benefit cost analysis of each of the three randomly selected projects is provided.

1 CRRDCC 2007, Guidelines for Evaluation, May.

2 Population refers to the total RDC investment portfolio over a minimum of three years.

3 BDA Group 2007, Cost Benefit Analyses of Research Funded by the Cotton research and Development Corporation, Report submitted to the CRDC, November.

2 SAMPLE DETAILS

A workshop was held in Canberra on Thursday 16th August 2007 to discuss issues surrounding the randomly selected projects. Attendees included representatives from some of the RDCs as well as a number of economic consultants that had been engaged by the RDCs to complete the benefit cost analyses. At that meeting concerns were raised about how the population should be defined and the sample selected to ensure that the sample was representative and results meaningful. Workshop participants agreed that ACIL Tasman[4] should conduct the random selection to ensure that the sample and results were both robust and representative of the population.

BDA Group consultants attended a meeting with CRDC staff and a representative from ACIL Tasman in Narrabri on 3rd October 2007 to agree on a suitable population and sample. ACIL Tasman suggested that the population should include all CRDC sub-programs where an investment had been made under the 2003 to 2008 Strategic Plan. Three projects were then selected at random by ACIL Tasman.

CRDC's 2003 to 2008 Strategic Plan is based around six Programs and 32 sub-programs[5]. The three sub-programs selected included:

1. Sub-Program 1.3 – Foster the development of opportunities for women in the cotton industry (***WINCOTT***).

2. Sub-program 4.3 – Strengthen our understanding of soil health and improve crop nutrition management (***Soil R&D***).

3. Sub-program 6.4 – The development of more accurate and repeatable technology of fibre measurement for neps, fineness, maturity and other fibre characteristics (***Fibre Classification***).

Cost benefit analysis was used in this study to derive financial sustainability measures. Evaluation guidelines developed by the CRRDCC were followed with economic, environmental and social benefits quantified where possible. Financial sustainability measures are only reported at the sub-program (project) level and no attempt has been made to reconcile these measures at the portfolio level.

This report differs from the Hero Study[3] in that the focus is on the sub-program investment rather than the outcomes achieved. Consequently, invested funds have only been considered at the aggregate CRDC level, including funds collected through the levy as well as the government matching contribution. Economic benefits to cotton growers are considered against the levy funds collected, while economic benefits to other sectors and environmental and social benefits are considered against the matching funds provided.

4 ACIL Tasman had been engaged to provide administrative support to the CRRDCC.

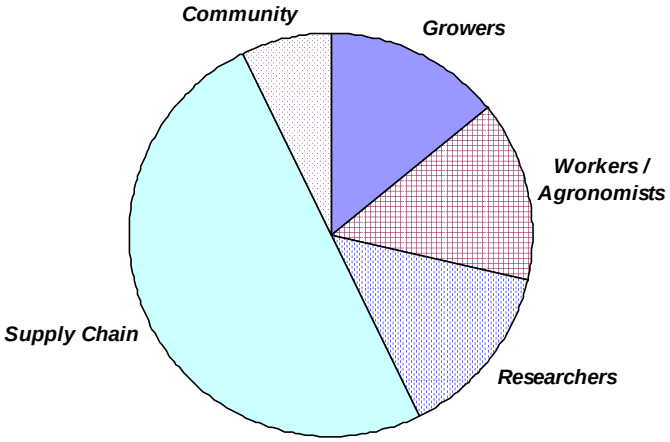
5 Sub-program detail are provided in CRDC 2003, Five Year Strategic Research and Development Plan 2003 – 2008, Narrabri.

3 CRDC PROJECT 1 – WINCOTT

The Women's Industry Network Cotton (WINCOTT) grew out of a meeting in Narrabri in 1998 of a number of concerned women involved either directly or indirectly with the cotton industry. Their main concern was that a lot of women missed out on information regarding the cotton industry as the information was mainly aimed at growers and delivered through traditional extension avenues with which women had little exposure. At that time there was increasing awareness in the community about cotton growing activities and many women involved with the industry felt that they had an inadequate understanding of the industry to make a meaningful contribution to discussions across the various community groups with which they were actively involved.

WINCOTT was formed in December 2000 with the specific aim of strengthening the linkage between industry and the community and to provide an avenue for communication between industry, research and government to women that have an impact on the cotton industry's perception in the community[6]. WINCOTT is active today with around 280 official members drawn from a wide range of backgrounds. As shown in Figure 1 women directly involved in the cotton growing and service industries make up the largest proportion of members. Building on the success of the network (it became self funding in 2005) membership has been expanded to include all partners of those engaged directly or indirectly with the cotton industry, not just women.

Figure 1: Breakdown of Member Background



WINCOTT provides members and the wider community access to information and training through meetings, newsletters, field days and issue specific seminars.

6 Role as specified in the WINCOTT Starter Kit – Welcome to the Cotton Industry document.

- Meetings include the Annual General meeting and periodic meetings such as the Strategic Planning meeting held in Dalby in 2004 to determine the strategy WINCOTT should adopt in the future, including sponsorship, structure of sub-committees, regional branches and membership.

- Meetings are also held with other organisations to strengthen WINCOTT's links with other groups. For example, WINCOTT members attended the government sponsored 2004 Women on Boards function in Tamworth and Brisbane, the 2005 meeting with 20 women from the sugar industry, the annual Australian Women in Agriculture meeting and the annual meeting of Queensland Women in Agriculture.

- A newsletter is prepared periodically to keep members up to date with WINCOTT activities, relevant industry information and links to other women and industry groups. In 2005 Ruth Quigley and Kate Schwager launched the WINCOTT website which provides a cost effective portal for members.

- Field days and information days are held at different geographical locations through time to ensure regional issues can be adequately addressed. These days provide an opportunity for all members to "get to" a WINCOTT function and enable guest speakers to keep members up to date with current issues as well as seeing first hand cotton producing, ginning and logistic operations.

- WINCOTT also arranges workshops and training seminars aimed at increasing member's skills in specific areas. To date WINCOTT has provided training opportunities for members to increase their skills in a number of areas including, for example, financial management, managing a business, media, staff management, and public speaking. A major part of the training program is delivered under the Australian Partnership in Cotton course.

3.1 CRDC Investment

CRDC first funded WINCOTT in 1999, providing funds for its establishment and administration and for the development and distribution of materials for its members. The level of support provided by CRDC has been modest and significant cost economies have been achieved because of CRDC's involvement in a wide range of other research and development activities across the industry.

A breakdown of the annual CRDC investment is provided in Table 1. WINCOTT became self funding in 2005 with support provided by a number of major sponsors including Monsanto, ANZ, Bayer Crop Science, Telstra, Drummuster and Grant Thorton Sydney. This support will ensure that WINCOTT continues to be relevant to its members and the broader community in the future.

Since 1999 a total of $82,482 has been invested by CRDC in WINCOTT. The early years involved more direct operational support with later year funding providing support for workshops and training seminars. CRDC has

also provided managerial support to the organisation through the participation of CRDC's Helen Dugdale as part of WINCOTT's executive team[7].

Table 1: CRDC Investment in WINCOTT

Year	CRDC Investment	Investment Purpose
1999/00	$32,140	Establish Structure and operations – APC course
2002/03	$9,127	Administration, workshops & training seminars
2003/04	$17,500	Administration, workshops & training seminars
2004/05	$5,500	Administration & support
2005/06	$18,215	Administration, website development – APC course
Total	***$82,482***	

From 2004/05 support has also been provided for selected members to undertake the corporate governance course for rural women. These funds were provided by the CRDC under the auspices of the Rural Industries Research & Development Corporation (RIRDC) and it is anticipated that this latter investment will continue for some time. Nearly $40,000 has been provided between 2004/05 and 2006/07 for this purpose. These funds have not been included in the evaluation as they are largely independent of WINCOTT.

3.2 Industry Outcome

CRDC's investment in the sub-program "*Foster the development of opportunities for women in the cotton industry*" has been successfully completed. The outcomes achieved can be appreciated from two perspective's: WINCOTT members; and the industry and community more broadly.

WINCOTT Members

As noted earlier the focus of WINCOTT has been on providing information and linkages to the wider industry, community and government. Grower members currently account for nearly 5% of the 1,000 farms[8] (mainly family run) that grow cotton in Australia, indicating that the network has achieved considerable penetration into its key market.

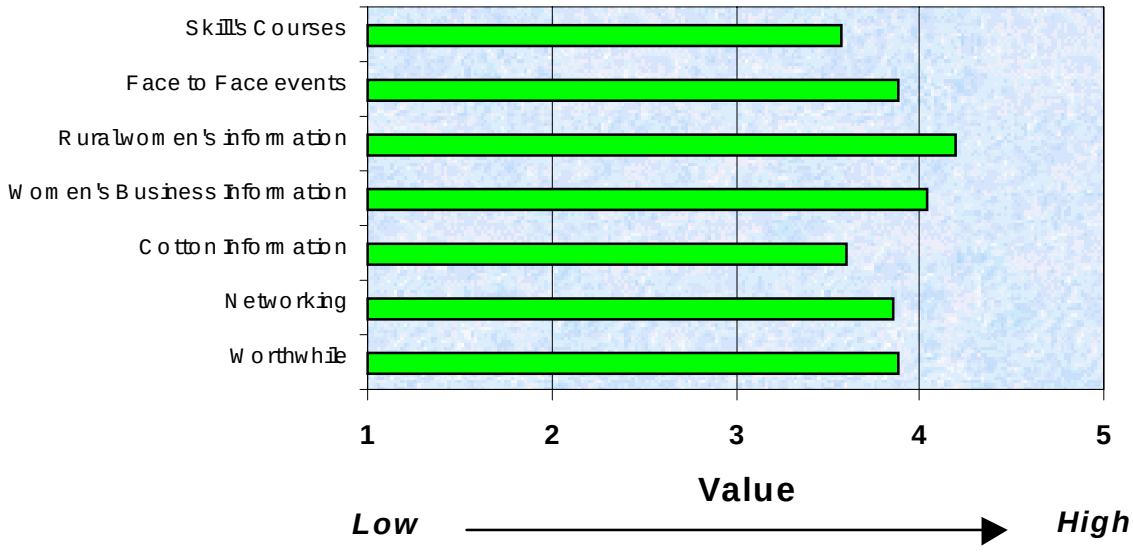
7 In-kind support has been estimated by CRDC at around 3 days a month since 2000. This support has not been included as it is treated here as a standard contract management activity and under the CRRDCC guidelines have been included as part of the evaluation of the total CRDC portfolio (Major Projects evaluation).

8 Cotton Australia Website

While anecdotal evidence suggests that WINCOTT has successfully delivered on its terms of reference, a survey of members was undertaken in December 2007 to seek more formal feedback on the overall success or otherwise of WINCOTT and specific services in particular. Members were asked to rate WINCOTT services between 1 and 5, where 1 represents least worthwhile (low satisfaction) and 5 represents most worthwhile (high satisfaction). The participation rate was around 10% and a summary of average survey responses is provided in Figure 2.

While WINCOTT has delivered value across a number of areas, the greatest value appears to be in information tailored specifically for women. With the achievement of self funding and a shift away from only engaging women (shift to including all partners) it is anticipated that cotton specific information will become more central to WINCOTT activities in the future. While no forecast has been made about future membership numbers, it is anticipated that membership will continue to grow. Two scenarios are considered in this evaluation. The first is a levelling out of membership at 280 to serve as a baseline and the second is a doubling of membership over the next 5 years.

Figure 2: WINCOTT Survey results



Another outcome that can be attributed to WINCOTT will be the increase in participation of women across industry, government and community groups. This outcome was identified under the National Plan for Women[9] in Agriculture in 1998 and was a guiding principle in its delivery across both Commonwealth and State governments. One of the main changes that has been attributed to action under the National Plan has been an

9 2003 Third Annual Implementation Report 2000 – 2001 of A Vision for Change – National Plan for Women in Agriculture and Resource Management.

increase in the participation of women on the FarmBis course, over 30%. This increase is consistent with the WINCOTT evaluation results that found that members valued business information highly. Although there has been no evaluation of the National Plan, the level of participation by women in Standing Committee on Agriculture and Resource Management funded programs and courses has been monitored through time, and there has been a steady increase since 2000.

While no survey has been undertaken to determine the possible increase in participation that might be attributed to WINCOTT it is likely that there has been more active participation of women in cotton farm businesses and at industry representative meetings. In addition, several WINCOTT members have undertaken the Australian institute of Company Directors residential course, which will serve them well in the future as they move into director positions.

Industry and Broader Community

Because WINCOTT provides an open door policy for many of its training days, seminars and workshops there will be benefits flowing to non-members. Also, one of the initial concerns addressed by the formation of WINCOTT was providing a better interface with community members regarding many of the issues surrounding cotton growing and processing operations. As members have gained a greater appreciation of the cotton industry it can be expected that this will have percolated down into the many community and social groups with which WINCOTT members are involved.

More direct outcomes have been achieved on a number of functions run by WINCOTT that serve local cotton growing communities. For example, activities in Emerald in 2005 raised over $3,500 for local charities and over 300 people attended the annual cotton dinner in Emerald.

3.3 The Counterfactual or Without Investment Scenario

WINCOTT has proven to be successful in reaching women actively involved in the cotton industry and promoting their contribution across business and community. The extent that this would have occurred without support provided to WINCOTT is difficult to appreciate, although many comments received from survey respondents indicated that without leadership and funding by an external agent (such as the CRDC) it is unlikely that the current outcomes would have been achieved to date, if at all.

From a broader perspective considerable focus has been provided by Federal and State governments, and while success has been achieved at a broad level there has been limited success within specific industries. However, successful industry groups like WINCOTT, Women in Dairy and Partners in Grain have leveraged off these broader initiatives.

The 1998 RIRDC report[10] identified six barriers to harnessing the potential of women in agriculture, with three that can only be addressed through groups that act at a "grass roots" level. These are an absence of role models and mentoring; lack of experience; and lack of training. WINCOTT, like other industry specific groups, tackle these barriers directly.

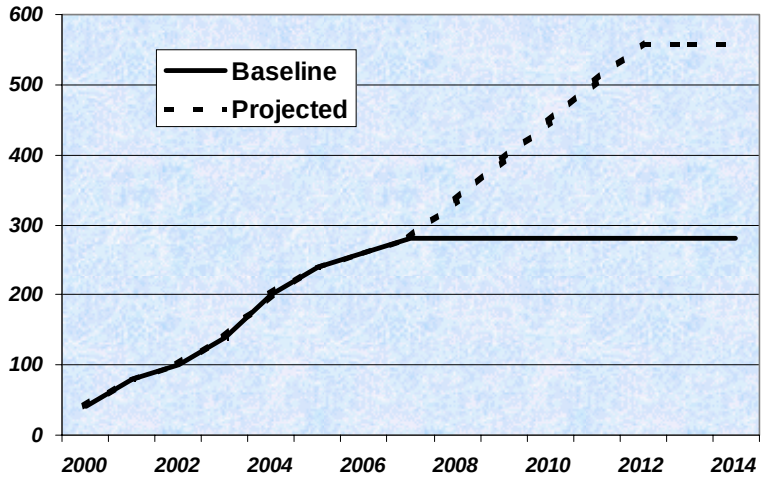
For the purpose of this evaluation it was assumed that without WINCOTT similar outcomes would have been achieved, albeit much later as the combined success of government initiatives and initiatives in other industries would have provided some momentum for change in the cotton industry. For the purpose of this evaluation a lag period of ten years was chosen to reflect the counterfactual or without CRDC investment scenario.

3.4 Triple Bottom Line Benefits

Although the greater engagement of women in the cotton industry will have flow on benefits in terms of economic gains to cotton growers and economic activity more broadly, these have been deemed as more indirect benefits and ones that would be difficult to quantify. Therefore, WINCOTT benefits are described in social terms only. The metric used to describe social benefits was taken as the number of WINCOTT members in any given year. Membership through time is shown in Figure 3 and reported in Table 1 for both the with and without CRDC funding scenarios and under the assumed baseline and projected membership scenarios.

The two membership scenarios discussed in Section 3.2 are based on a baseline where there is assumed to be no further increase in WINCOTT membership. This scenario therefore represents the minimum benefit achieved. The second scenario, based on a doubling of membership over the next 5 years, was used to provide some indication of benefits under a growing WINCOTT membership.

Figure 3: WINCOTT Membership through Time



10 RIRDC (1998) Missed Opportunities – Harnessing the Potential of Women in Agriculture, Canberra.

Table 2: Social Benefits Through Time: With and Without CRDC Funding Scenarios

Year	Baseline			Projected		
	With	Without	Difference	With	Without	Difference
2000						
2001	80		80	80		80
2002	100		100	100		100
2003	140		140	140		140
2004	200		200	200		200
2005	240		240	240		240
2006	260		260	260		260
2007	280		280	280		280
2008	280		280	336		336
2009	280		280	392		392
2010	280		280	448		448
2011	280	80	200	504	80	424
2012	280	100	180	560	100	460
2013	280	140	140	560	140	420
2014	280	200	80	560	200	360
2015	280	240	40	560	240	320
2016	280	260	20	560	260	300
2017	280	280		560	280	280
2018	280	280		560	336	224
2019	280	280		560	392	168
2020	280	280		560	448	112
2021	280	280		560	504	56
2022	280	280		560	560	
2023	280	280		560	560	

3.5 Financial Sustainability Measures

Financial sustainability measures have been derived for the Australian community at large because only social benefits are considered. Further, CRRDCC evaluation guidelines for the derivation of financial sustainability measures are based on cost benefit methods. These methods are not applicable here because benefits have not been quantified in monetary terms. Instead, a cost effectiveness approach has been used as this provides a measure that can be compared across other investments that seek to increase the participation rate of women in agriculture.

In the cost effectiveness approach the discounted sum of annual investment cost is divided by the discounted annual number of members that can be attributed to the investment. CRDC costs were converted to current dollars using the consumer price index. The cost effectiveness value can be interpreted as the total cost per member per year and is reported in TABLE 3 below for the evaluation periods requested under the CRRDCC

guidelines. The cost per member per year was estimated under the projected membership trend to be around $25. The cost per member per year to date was estimated at $67.

TABLE 3: FINANCIAL SUSTAINABILITY MEASURES: RETURNS ON ALL FUNDS: PROJECTED MEMBERSHIP

Measure	To date	5 years out	10 years out	20 years out
Cost per Member	$67	$33	$26	$25

3.6 Conclusion and Sensitivity Analysis

Given the success of the WINCOTT network and the likelihood that membership will increase through time, the cost effectiveness of the investment was estimated at $25 per member per year. If WINCOTT membership remains at 280 in the future then the cost per member per year will be higher than that estimated under the projected membership scenario. Under the baseline membership scenario where membership was assumed to remain at 280 in the future the cost per member was estimated at $43 per member.

TABLE 4: FINANCIAL SUSTAINABILITY MEASURES: RETURNS ON ALL FUNDS: BASELINE

Measure	To date	5 years out	10 years out	20 years out
Cost per Member	$69	$45	$43	$43

The estimated return on government funds (as part of matching contributions) was estimated at $13 per member per year under the projected membership scenario. Whether or not this represents a viable return for the commonwealth depends on comparative returns they have been able to achieve on their other investments in increasing the engagement of women in agriculture.

4 PROJECT 2 – SOILS RESEARCH

Soils research has been a major component of CRDC's investment portfolio over many years. For the 2003 to 2008 Strategic Plan the focus of the research shifted to improving nutrient management and soil quality. Between 2003/04 and 2005/06 CRDC's investment in the soil health and nutrition sub-program totaled $4.5m.

The soil health and nutrition sub-program provides a good example of the problems that can be encountered when triple bottom line evaluation is applied at the sub-program level. Soil research typically involves extensive field experiments over a long period of time. The existence of field experiments provides a base upon which a range of other related scientific research can be carried out, and this has been the case here. Triple bottom line evaluation centres around an identifiable industry outcome that can lead to the generation of industry benefits. Taking a snap-shot of research over the period 2002/03 to 2005/06[11] can be misleading because identified outcomes often involved R&D that was undertaken prior to this period and, likewise, much of the current R&D activity underpins future investment. Therefore, to ensure consistency with other evaluations the improvement in nitrogen management was chosen as the key outcome and R&D investments through time that contributed to this outcome included.

The two leading researchers in nitrogen management funded by the CRDC are Dr Rochester (CSIRO) and Dr Hulugalle (NSW Department of Primary Industries). R&D undertaken and managed by these two researchers have considerable overlap, with Dr Rochester's work examining applied nutrients while Dr Hulugalle's work mainly related to exchangeable cations, hydrology and soil physical properties. These researchers have also undertaken related work in examining the impact of transgenic crops on nutrient management, phosphorus and potassium management, sodium build-up and broader profit impacts of different crop rotations. The other main component of the sub-program has been an examination of soil biology or health. Work in this area involves research on soil microbiota and their contribution to cotton yields through time. This work is on-going.

4.1 CRDC Investment

Total sub-program funding between 2002/03 and 2005/06 was $4.5m with $1.7m invested in soils biology, $1.2m in nutrition and $1.6m in crop rotations. Investment made in improved nitrogen management over this period was close to $1m. Several R&D investments made prior to the evaluation period were also included, as shown in Table 5. While these earlier investments would have contributed to other R&D outcomes they have made a substantial contribution to the R&D carried out over the evaluation period[12].

11 This was the period used in the Hero Study. The randomly selected projects were considered for this period to show the possible ranges in returns as opposed to the "high payoff" investments that the were included in the Hero Study..

12 As noted earlier it can be difficult to identify what R&D investments have resulted in a given outcome as R&D outputs are typically taken up and used in many different areas – and hence outcomes that are generated. Our approach has been to

Table 5: NITROGEN MANAGEMENT R&D THROUGH TIME: CRDC PROJECTS

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CSP 54												
				CRC 1								
					CRC 10c & CRC 26c							
					CRC 12							
										CRC 45		
										CRC 52		
											Extension	

4.2 Industry Outcome

Nitrogen is applied to cotton crops in Australia because there is an inadequate supply of soil nitrogen to meet the demands of high yielding cotton crops. Nitrogen fertilisers used in Australia are anhydrous ammonia and urea. Fertiliser is applied prior to and throughout the growing season to support plant growth. Research completed to date has shown that the volume of nitrogen fertiliser currently applied to cotton crops can be reduced without any significant loss in cotton yields.

In Figure 4 the relationship between applied nitrogen and cotton yields is shown[13] for cotton crops grown in different rotation[14] systems. Cotton plants need around 180 kg per ha of nitrogen and take up most of this from nitrogen in the soil. This nitrogen is mineralised from soil organic matter and from nitrogen fixation from leguminous crops. About two thirds of the nitrogen required by a cotton plant is taken from soil reserves. The remainder is supplied through fertilisers. If too little nitrogen is applied then plant growth will be retarded and

identify a significant outcome within the sub-program and then try to link past R&D to that outcome. We appreciate that this might overstate the costs, but this will be offset to some degree as other related work will have been excluded.

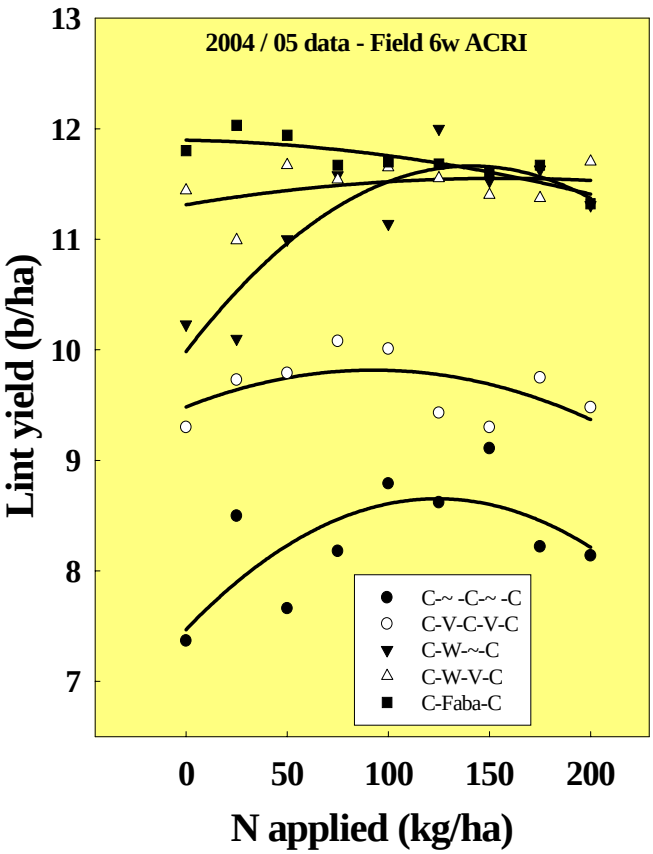
13 This data was supplied by Dr Rochester and relates to 2004/05 response curves for a number of experimental fields.

14 Hulugalle, N.R. & Scott, F (2008), A review of changes in soil quality and profitability accomplished by sowing rotation crops after cotton in Australian vertosols from 1970 to 2006. Aust. J. Soiul Res., 46 (2), In press – report that over 80% of cotton is grown in a rotation system with rotations first used in the 1960',s and 1970's.

yields will be low. As more fertiliser is applied cotton yields increase, but only up to a point beyond which cotton yields fall because of rank growth and fruit shedding[15].

Nitrogen fertilisers are applied at varying rates, depending on the rotation system used, but can be applied at rates of up to, and sometimes exceeding, 200 kg per ha. Most cotton growers apply nitrogen fertilisers based on their experiences, and while field history, soil and plant test results are all used, the tendency is to over fertilise as the risk of potential income loss from reduced cotton yields is considered to be significantly greater than the additional cost of increasing the fertiliser application rate to ensure good yields.

Figure 4: Applied Nitrogen Response Curves



2 year rotations are indicated as:

C C C	continuous (annual) cotton
CvCvC	continuous (annual) cotton with vetch (green-manured) each winter
CW~C	cotton wheat fallow cotton
CWVC	cotton wheat vetch cotton
CFaba~C	cotton fababean (grain) fallow cotton

Through the CRDC funded R&D into nitrogen applications and crop rotations a tool that assists growers to predict the fertiliser requirement of their crop has been developed. This tool - NutriLOGIC – is discussed in the COTTONpaks series and available on-line through the Cotton Catchment Communities CRC (Cotton CRC) website (www.cottoncrc.org.au). The tool assists a cotton grower to estimate their nitrogen fertiliser application

15 Details of nitrogen requirements and impacts on cotton yield were sourced from the COTTONpaks CD.

rate more accurately and in most cases reduce the amount of nitrogen applied. There is an active extension program, supported by the CRDC, that is being run out of the Cotton CRC that is developing and testing a protocol for cotton growers to monitor their nitrogen use efficiency. The aim of the program is to develop a low cost method for cotton growers to assess nitrogen use efficiency on each field at the lowest possible cost. This program is also promoting the use of NutriLOGIC (and the required soil and leaf test). While savings will vary from farm to farm, average savings of around 40 kg nitrogen per ha have been identified[16].

Adoption of methods to measure nitrogen use efficiency on farm plus NutriLOGIC is just commencing and ultimate take-up will not be known for some time. For the purpose of this evaluation a moderate rate of take up was assumed (over 5 years) because there is likely to be some resistance as the technology requires additional tests to be carried out and there will remain a perception that losses might be incurred if "you get it wrong". Further, BDA Group assumed that the technology would penetrate around 60% of the market – or 60% of the area sown to cotton[17]. The impact of this assumption on derived financial sustainability measures is tested with sensitivity analysis.

4.3 The Counterfactual or Without Investment Scenario

Soils and nutrition R&D is complex and often involves long term field experiments. If the CRDC had not supported this work it is unlikely other public R&D agencies would have continued work in this area and therefore any development would have occurred through grower trial and error and professional advisers (such as agronomists). Given that most cotton growers deliberately over-fertilise as an insurance against getting application rates wrong, it is likely that progress in this area would have been slow without CRDC support. A research lead of 10 years was chosen for this analysis, reflecting the long period over which R&D is required to make significant industry advancements.

4.4 Triple Bottom Line Benefits

Benefits from the soil R&D considered in this evaluation will be driven by the extent to which nitrogen savings are achieved as cotton growers better match nitrogen supply with crop demand. This will depend on the area of cotton grown each year and the level of adoption of better fertiliser management through use of the NutriLOGIC tool and associated soil and leaf tests.

16 Rochester I, O'Halloran J, Maas S, Sands D, Brotherton E (2007) Monitoring nitrogen use efficiency in your region. Australian Cotton grower magazine. (Aug 2007 p22).

17 No estimates on potential rates of adoption were available. A moderate to high rate of adoption was assumed because the benefits are evident to growers (cost saving) and application rates can be easily adjusted.

In TABLE 6 the with and without scenarios are shown[18]. Production in 2007/08 came off a low level of planting in 2006/07 due primarily to protracted drought conditions. The area sown to cotton is forecast to increase up to 2011/2012 and for the purpose of this evaluation is assumed to remain at that level for the remainder of the evaluation period (to 2027/28).

TABLE 6: WITH AND WITHOUT ADOPTION SCENARIOS: AREA WHERE NITROGEN SAVINGS REALISED: "000 HA

Year	Area Planted	With CRDC R&D	Without CRDC R&D	Difference
2008	190			
2009	226	27		27
2010	260	62		62
2011	304	109		109
2012	356	171		171
2013	356	214		214
2014	356	214		214
2015	356	214		214
2016		214		214
2017		214		214
2018		214		214
2019		214	27	186
2020		214	62	151
2021		214	109	104
2022		214	171	43
2023		214	214	

Note: Years are expressed in financial years. 2008 refers to the 2007/08 financial year.

Economic

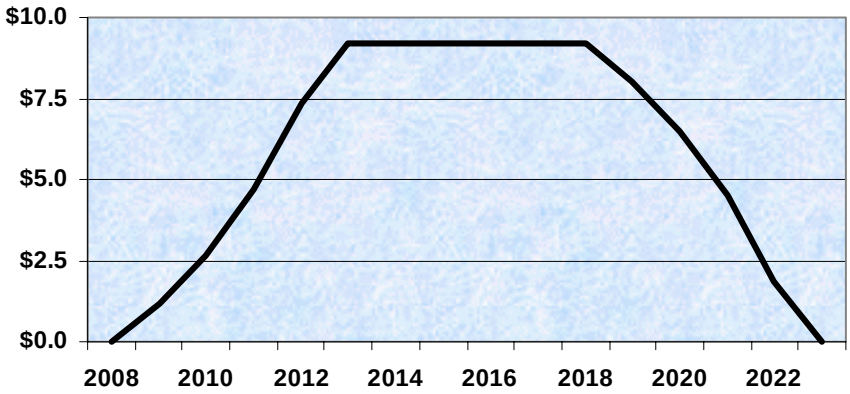
The economic benefit generated on CRDC's investment in soils R&D will be based on the saving to cotton growers from reduced fertiliser application. The fertiliser saving has been estimated at, on average, 40 kg per ha. At a cost of some $1.20 per kg of nitrogen the potential saving would be $48 per ha[19]. This represents a 20%

18 Area sown was sourced form ABARE Australian Commodity Statistics and Forecasts and is consistent with areas sown assumptions used in the 2007 "hero" Study.

19 It is appreciated that fertiliser prices have increased dramatically this season – to $1.50 kg or more – but it is not known whether this is a fundamental shift in prices or reflective of current supply and demand conditions. In this study a long term average (real

saving in the average fertiliser cost[20]. To achieve the estimated fertiliser saving a cotton grower would need to carry out soil and leaf tests. The cost of these tests is estimated at $5 per ha. Hence, the net benefit that can be attributed to the R&D is estimated at $43 per ha. Aggregate benefits through time are shown in Figure 5 and are expected to reach a maximum of $9m a year by 2012/2013.

Figure 5: Estimated Net Benefits through time from CRDC Investment: $m



Environmental

Reducing the application rate of nitrogen on cotton crops will have an impact on the associated production of greenhouse gases. When nitrogen is applied to cotton crops less than 30% is actually taken up by the plant. Some of the remainder is converted to an organic form that remains in the soil and is unavailable to the cotton plant. The rest is lost to the plant / soil system (42% of the nitrogen applied) through leaching or denitrification. Denitrification is the process where applied nitrogen is converted to a gas, either pure nitrogen or nitrous oxide[21]. The latter is a greenhouse gas that is thought to be a contributor to global warming.

A simple greenhouse gas calculator for the Australian cotton industry has been developed[22]. This calculator is available on the Cotton CRC website (www.cottoncrc.org.au) and was used to estimate the potential greenhouse

dollars) of $1.20 per kg has been used as a price of nitrogen into the future. If prices remain high well into the future then investment benefits will be, to some extent, underestimated.

20 CRDC funded *Australian Cotton Comparative Statistics 2005 crop* by Boyce Charted Accountants.

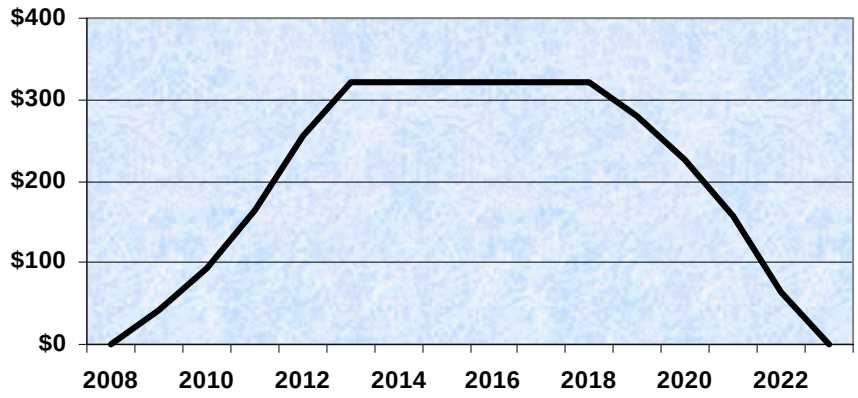
21 These losses are detailed in the Cotton Catchment Communities CRC NUTRIpak.

22 The primary researcher has been Dr Peter Grace, Professor of Global Changes and Sustainable Systems at the Queensland University of Technology and is based on emissions research undertaken since 2003 and funded by CRDC, AGO, CRC for Greenhouse Accounting and the Australian Cotton CRC.

gas saving from reducing the rate at which nitrogen is applied to cotton crops. It was estimated that a 40 kg per ha saving in applied nitrogen would reduce greenhouse gas emissions by 100 kg of $CO_{2\text{-}e}$ per ha.

When a carbon trading scheme is implemented in Australia (this is a stated federal government policy) carbon will trade at a price that can be used to value greenhouse gas abatement strategies. While the carbon price will vary through time BDA Group has assumed in this evaluation that carbon will trade at around $15 per tonne of $CO_{2\text{-}e}$. At this price the environmental saving from reducing nitrogen application rates would be some $1.50 per ha. The estimated saving through time was estimated to reach a maximum of $320,000 in 2011/12. Savings through time are shown in Figure 6.

Figure 6: Estimated Environmental Benefits through time from CRDC Investment: $'000



Social

The CRDC has supported soils R&D over a long period of time. As stated earlier, soils R&D is complex and usually undertaken over long periods as considerable field experimentation is required. Much of the investment in the soils R&D program contributes to a wide range of other related work such as plant, pest and weed R&D. No attempt is made here to quantify the contribution that the soils R&D program makes to other areas of R&D.

Investment made in the Soils R&D program also involves support for travel so that Australian researchers can keep up to date with developments overseas and there has also been a provision made to support post graduate projects. In many respects the support provided by CRDC funding for the key researchers in the soils/nutrition program provides the basis of expertise, co-supervision and field site access that is required to support post-graduate students. While such benefits are recognised here, costs associated with travel and training have been excluded.

The final area where social benefits are likely to be realised is in the flow on impacts to the wider community following increased cotton production with reduced environmental impact. Increased cotton production will occur in response to the additional profits generated from nitrogen cost savings on cotton farms. BDA Group (2004[23]) estimated that every additional dollar in added profitability on cotton farms would lead to an increase in cotton production valued at 80 cents. This increase in production would have an impact in regional economies in terms of additional demand for goods and services as well increased demand for labour. These benefits are reported in the following section.

4.5 Financial Sustainability Measures

Financial sustainability measures derived included the net present value (NPV), benefit cost ratio (BCR) and internal rate of return (IRR) on CRDC's investment. A discount rate of 5% was used and all dollar values were converted to 2008 dollars using the consumer price index. A summary of investment costs and benefits is provided in Table 7.

Table 7: Program Costs and Benefits: $'000

Year	CRDC Costs		Levy Payer	Australian Community Benefits		
	Levy	Matching	Benefits [a]	Environmental	Flow-on	Employment
1994	$88	$88				
1995	$83	$83				
1996						
1997						
1998	$87	$87				
1999	$88	$88				
2000	$189	$189				
2001	$104	$104				
2002	$107	$107				
2003						
2004	$193	$193				
2005	$203	$203				
2006	$179	$179				
2007	$113	$113				
2008						

23 BDA Group 2004 evaluation of Australian Cotton CRC outcomes.

Table 7 - continued: Program Costs and Benefits: $'000

Year	CRDC Costs		Levy Payer	Australian Community Benefits		
	Levy	Matching	Benefits [a]	Environmental	Flow-on	Employment
2009						
2010			$1,015	$35	$309	$40
2011			$2,334	$81	$710	$91
2012			$4,094	$142	$1,246	$160
2013			$6,393	$223	$1,946	$250
2014			$7,991	$278	$2,432	$313
2015			$7,991	$278	$2,432	$313
2016			$7,991	$278	$2,432	$313
2017			$7,991	$278	$2,432	$313
2018			$7,991	$278	$2,432	$313
2019			$7,991	$278	$2,432	$313
2020			$6,976	$243	$2,123	$273
2021			$5,656	$197	$1,722	$221
2022			$3,897	$135	$1,186	$152

Note: Costs are presented in current dollars. (a) Cotton growers capture 87% of reported economic benefits as reported in BDA Group's CRDC Hero Study

Levy Payers

Financial sustainability measures were derived first for levy payers. Relevant costs include payments made by growers via the output levy on cotton production and relevant benefits include only those gains to cotton growers. Financial sustainability measures are reported in the table below along with a breakdown by benefits realised to date and by 5, 10 and 20 years from now.

The payoff to levy payers was estimated at $24m in net present value terms. The low IRR reflects the long time period over which benefits will be realised. The low pay off to date reflects the fact that benefits are not expected to be realised until 2009/2010.

TABLE 8: FINANCIAL SUSTAINABILITY MEASURES: RETURNS TO LEVY PAYERS

Measure	To date	5 years out	10 years out	20 years out
PVB	$0m	$5m	$18m	$25m
PVC	$1m	$1m	$1m	$1m
NPV	-$1m	$4m	$18m	$24m
BCR	0	6	20	26
IRR	na	21%	28%	29%

Note: PVB is the present value of benefits and PVC is the present value of costs

Australian Community

The second segment for which financial sustainability measures were derived was the Australian community at large. Relevant costs include payments made from matching funds received by the CRDC and relevant benefits exclude gains to cotton growers. Financial sustainability measures are reported in TABLE 9. The estimated pay off on the government investment was estimated at $8m in net present value terms.

TABLE 9: FINANCIAL SUSTAINABILITY MEASURES: RETURNS TO AUSTRALIA

Measure	To date	5 years out	10 years out	20 years out
PVB	$0m	$2m	$7m	$9m
PVC	$1m	$1m	$1m	$1m
NPV	-$1m	$1m	$6m	$8m
BCR	0	2	7	10
IRR	na	12%	21%	22%

Note: PVB is the present value of benefits and PVC is the present value of costs

4.6 Conclusion and Sensitivity Analysis

The estimated payoff from CRDC's investment in the soils R&D program, using only benefits generated from reduced application of nitrogen fertiliser on cotton farms, was a return of $26 for every dollar of levy funds invested. The two main factors driving investment benefits will be the nitrogen saving achieved on-farm and the extent to which the saving is realised across the industry (adoption). To test the robustness of the nitrogen saving (40 kg per ha) and adoption (maximum 60% penetration) assumptions sensitivity analysis was carried out on these variables. The estimated BCR is reported for a range of assumptions in Table 10.

Table 10: Sensitivity Analysis: BCR

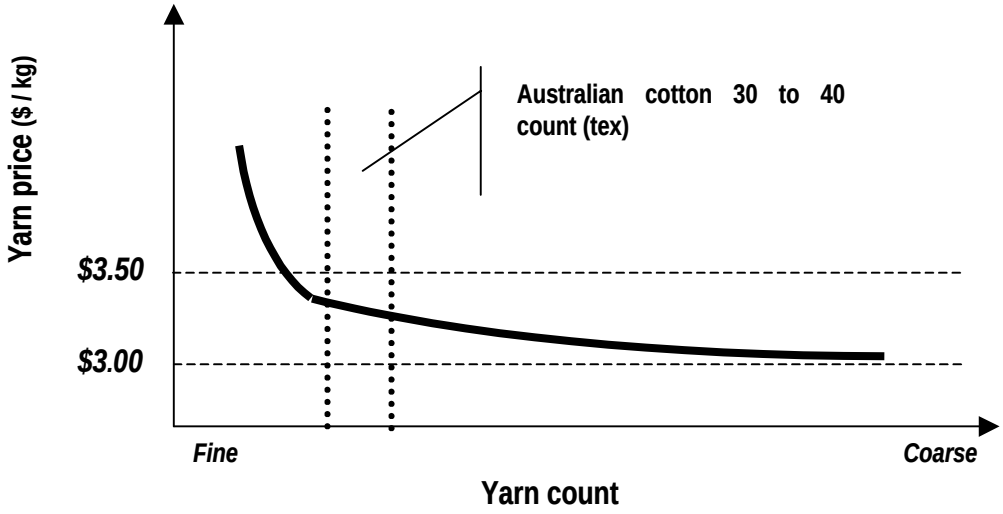
Maximum	***Nitrogen Saving (kg per ha)***				
Adoption	5	10	15	20	40
10%	0	1	1	2	4
20%	0	1	3	4	9
30%	0	2	4	6	13
40%	0	3	5	8	18
50%	1	4	7	10	22
60%	1	4	8	12	**26**

The estimated pay off to levy payers was found to be more sensitive to the assumed rate of adoption rather than the nitrogen saving per ha. At a nitrogen saving of only 10 kg per ha or more the CRDC investment was found to deliver a positive return to levy payers. However, if the saving is only realised across a small number of cotton farms it is unlikely that the investment would deliver a positive return to levy payers. Given that the nitrogen saving is likely to be substantial and that a well established and grower accepted extension mechanism exists it is anticipated that the CRDC supported investment will deliver a positive return through time.

5 PROJECT 3 – FIBRE CLASSIFICATION

Australian cotton growers face a competitive world market where the price of raw cotton is determined by the consumer demand for cotton products, which in turn is influenced by consumer incomes, preferences, changes in fashion and changes in cotton prices relative to prices of competing fibres. Higher prices are received on fine yarns, especially below a count of 30 tex[24] where price increases on finer yarns are large. The relationship between yarn count and prices[25] is shown in Figure 7.

Figure 7: Yarn Prices for different yarn fineness (count in tex)



Most of Australian cotton is used to produce yarns in the medium to fine end of yarn count (tex). Because the majority of Australian cotton is sold on export markets, where it is blended with other cottons from around the world (usually US, West African or Brazilian), little is known about the ultimate products that are produced[26]. However, prices for cotton are determined on a competitive basis with trade in raw cotton dominated by international trading companies. Some 19 companies handled nearly 40% of world production with seven being US based[27]. Prices paid for raw cotton are largely influenced by its country / region of production, whiteness, length, strength and micronaire.

24 Count in tex is a measure of the fineness of a year and is measured in grams of yarn per length (1 km).

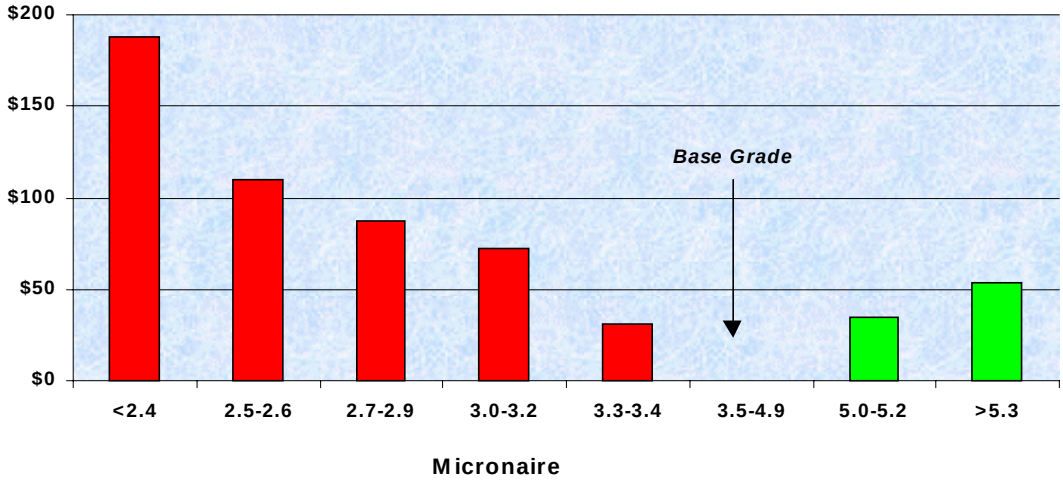
25 Derived from a CSIRO & Deakin University paper 2008 Adding value to Australian cotton fibre – A discussion paper on R&D strategies for adding value to Australian cotton. Prices are based on international prices over 2007

26 Paper by Morison & Tomkins 2008, Market opportunities for Australian long staple cotton – prepared for as part if CRDC's 2008-2013 strategic plan

27 Larsen, M.N. (2003 Quality standard-setting in Global cotton chanin and cotton sector reforms in sub-Saharan Africa, IIS/GI. Kongevej Wiorking paper, 03.7, Copenhagen, August.

The development of objective measurement in the cotton industry mainly occurred during the 1980s and became established in the industry in 1993 when the US Department of Agriculture provided objective measurements on all cotton bales produced in the USA. Premiums and discounts are paid on a range of fibre characteristics, including micronaire, which is a combination of both fibre fineness and fibre maturity. The micronaire discounts[28] on Australian cotton are shown in Figure 8. There is a base grade where no discount is applied, although in some cases a small premium is paid for cotton with a micronaire of between 3.7 and 4.2. If the recorded micronaire is higher (indicating coarser or more mature fibres) or lower (indicating finer or less mature fibres) a discount is applied.

Figure 8: Discounts on Australian Cotton: By Micronaire: $ per Bale



A similar base grade is applied for most cotton, irrespective if it is used to produce fine or coarse yarns. This is because the micronaire measurement does not provide an accurate measurement of either fibre fineness or fibre maturity, and that fibre length and strength are also critical attributes in determining the fineness of yarn produced from raw cotton. Fibre fineness is largely influenced by variety while maturity is largely influenced by seasonal conditions in any given year. By choosing raw cotton within the base grade there is a high chance that the fineness and maturity of the fibre will be satisfactory to produce the desired yarn. This risk management strategy adopted by spinners is illustrated in Figure 9.

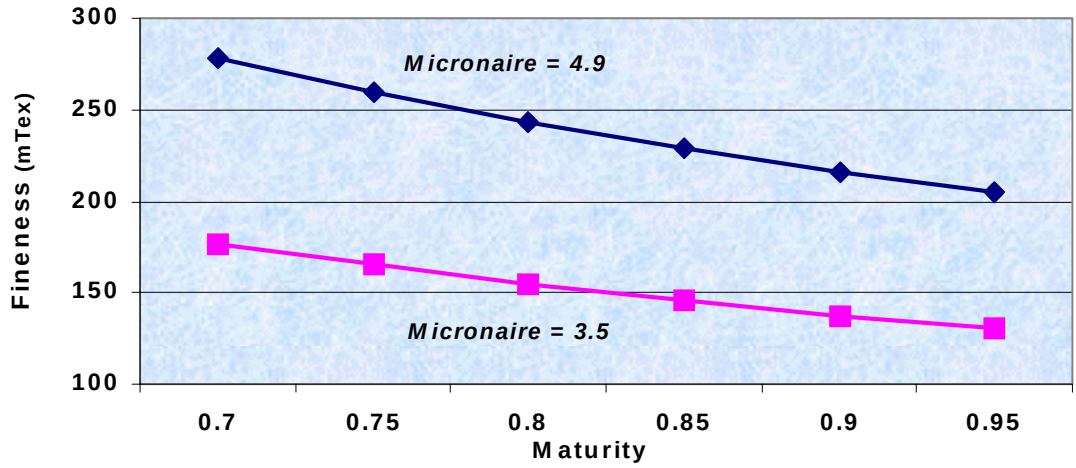
A base grade for the fineness for a standard yarn is around 200 m tex[29]. As shown in Figure 9 a micronaire reading in the base grade would give a high likelihood that the actual raw fibre is around the 200 mtex, even if

28 van der Sluijs, M.H.J., Gordon, S.G & Long, R.L. 2007, A spinners perspective on fibre fineness and maturity Part 1: Current practice based on micronaire, CSRIO Textile & Fibre Technology, Prepared for Australian cotton grower magazine, Geelong

29 Lord, E., Airflow through plugs of textile fibres. Part II, *J Textile Inst.*, **47**, T16-47, 1956 fineness * maturity = 3.86 micronaire ^2 + 18.16 micronaire +13

the fibre is immature (0.7). Because there is a standard price of cotton within the base grade no premium is given for more mature fibres or finer fibres, yet the differences can be substantial.

Figure 9: Fineness and Maturity Values within the Cotton Base Grade



Researchers have recognised the inadequacy of the micronaire measurement and sought to develop new technologies for measuring fineness and maturity in a commercial operation. While methods exist for research purposes they tend to be complex and slow which limits their commercial appeal. CRDC recognised the need for increased objective measurement in the global cotton industry and commissioned CSIRO, a world leader in the development of objective measurement for fibres, to develop a more accurate and repeatable technology for fibre maturity and fineness measurement that was viable in commercial operations. If successful such technologies would support changes to the traditional classifications system for cotton and better identify and reward superior fibre characteristics.

5.1 CRDC Investment

CRDC first provided R&D funding to CSIRO in 1997/98. This investment was aimed at the development of a technology to measure fibre fineness (Cottonscan). In 2000/01 an additional investment was made in the development of a technology to measure fibre maturity (Siromat). To date significant progress has been made on the development of these two technologies. CSIRO has applied for patents for the two technologies and commercialisation pathways are currently under examination.

Since 1997/98 CRDC has invested over $2m in the development if these technologies. Substantial investment has also been made by CSIRO and more recently by the Cotton CRC. Further investment is proposed for the continued development and commercialisation of the two technologies. It is anticipated that one of the two technologies might be commercially available within 3 years.

5.2 Industry Outcome

Two industry outcomes are considered in this evaluation. Both involve the successful development and commercialisation of one of the two technologies. There stills remains some risk, especially in getting the technologies to perform with the same throughput as current equipment, such as the High Volume Instrument (HVI) marketed by Uster. For the purpose of this evaluation it was assumed that the chance of successful commercialisation of one of the two technologies was 50%[30].

The first outcome considered in this evaluation was use of the technology to better reward (through price) the desirable fibre characteristics of fineness and maturity. The second outcome considered was the generation of a royalty on equipment sales. The two outcomes are dependent on each other because the evolution of a new pricing system would require the commercial use of the technology.

Price Impacts

If the technology were widely used, and more importantly, recognised by leading traders and spinners, cotton breeders could focus their efforts on producing finer more mature cottons for which a premium might be earned. The evolution of such a premium would require a movement away from the base grade pricing system, and as such would represent a fundamental shift in the classification of cotton. If such a change were to occur the CRDC is confident that Australian cotton breeders could develop finer, mature cotton to take advantage of any premiums that might evolve. Possible premiums that might be earned are discussed in the following section.

The realisation of any price impacts is likely to take some time following the take up of the technology across the industry. Breeding and release of different varieties is estimated to take an additional 5 years[31], although once developed take up would be rapid – as evidenced by adoption of past varieties including transgenic cotton. Hence, price impacts might be realised by 2016.

Another price impact that was considered here was the possibility of a new pricing system being applied to Australian cotton that was currently discounted because it had a micronaire reading outside the base grade. Such a discount might be avoided if it were demonstrated that the fibre was fine but mature.

30 No assessment of risk has been made by either CSIRO or CRDC. The assumed risk of 50% was chosen by BDA Group based on their experience with the commercialisation of other technologies. The impact of this assumption on investment returns was tested with sensitivity analysis.

31 This value was sourced from the Cottonscan business plan 2008. It was recognised that the USDA would require a period of time for detailed trials and this would therefore confer a competitive lead time to Australian breeders, assuming that they were confident that price premiums would ultimately be paid on finer and mature cotton. Given the world-wide interest in technologies to measure fineness and maturity it is reasonable to assume that most breeders would be positioning themselves accordingly.

Because testing would invariably be done across the board (to support a new pricing system) the net gain to the industry might be small as coarser and immature cotton was appropriately discounted. Consequently, these price impacts have been excluded.

Royalty on sales

The two CSIRO technologies are covered by patents, and if first to the market, would protect their possible level of penetration. There is considerable research investment internationally, particularly in the USA, in the development of more accurate and high throughput technologies to measure fibre fineness and maturity. Given that the global industry (especially in the high and medium quality end of the market) recognises the limitations of the micronaire measurement, it is anticipated that market uptake would be rapid, especially in the US where testing is managed by the US Department of Agriculture (USDA).

The most widely used technology for the objective measurement of cotton is the HVI system. There are around 2,600 systems in use world-wide, with 290 used by the USDA Agricultural Marketing Service and 420 planned for the Chinese Fiber Inspection Bureau by 2010[32]. While no detailed pathway for sales of the proposed CSIRO technologies have been considered because there still remain some technical hurdles, for the purpose of this evaluation it was assumed that the initial market might be the USDA followed by other current users of the HVI system. Uptake across the USDA would be rapid, especially if a new pricing system were to evolve. It was assumed that the new technology would be taken up over a period of three years. For the remainder of the current HVI market it was assumed that the rate of technology take-up would be slower, at 10 years (which reflects the current replacement rate).

Again, the size of the royalty and the cost at which the CSIRO technologies might sell for needs to be determined. For the purpose of this evaluation it was assumed that the royalty earned on each sale would be $5,000. This was based on an assumed sale price of $100,000 and a royalty of 5%.

5.3 The Counterfactual or Without Investment Scenario

Without CRDC investment it is unlikely that R&D agencies in Australia would have invested funds in this area. Further, there is limited capacity within the Australian spinning industry given its relatively small size compared to total Australian cotton production. However, there has been, and continues to be, significant interest and investment internationally in this area. Results to date from overseas have been limited and CSIRO's success in this area is widely recognised.

One difficulty with research in this area is that there were no internationally recognised standard cotton samples that could be used for checking the accuracy of new measurement technologies or for checking the accuracy

32 Data supplied by CSIRO.

and calibration of exiting equipment. The international community has participated in inter-laboratory projects with CSIRO staff to develop standards for both fineness and maturity. The extent to which CSRIO is ahead of the international research community was assumed to be six years. This reflects the fact that the international R&D community was still at the technology feasibility stage in 2002/03 (CSIRO technology patent date) compared to CSIRO that was at this stage back in 1997/98.

Consideration of the counterfactual of six years is only required for price impacts. For royalties earned no counterfactual is relevant, as the patent will provide market advantage over the period considered in this evaluation (twenty years).

5.4 Triple Bottom Line Benefits

Benefits considered in this section are based on the CSIRO developed technology being used widely across the global cotton industry by 2016. Economic and environmental benefits are estimated.

Economic

Economic benefits from technology use will be driven by the extent to which finer cotton can be produced in Australia. Premiums for finer cotton are not easily disentangled from the current pricing system and therefore some estimation of the possible gains from "going finer" needs to be made.

Since 2000 the proportion of Australian cotton production falling in the greater than 5 micronaire grade has increased, and is currently around the 10% mark[28]. If breeders are successful in reducing the average fineness of cotton produced in Australia then the potential premium might be given by the discount avoided on 10% of production that exceeds 5 micronaire and not offset by the possible increase in cotton falling into the 3.2 micron or less grade. This discount is around $35 per bale, as shown in Figure 8. Assuming production of 3 million bales from 2016 onwards[33] and 10% in the 5 micronaire grade and above the annual benefit would be around $10m. In terms of average prices received this represents an increase of nearly 1%.

Gauging the robustness of an assumed 1% increase in the price received for Australian cotton from breeding finer cotton was tested. First, as shown in Figure 7, the price of yarn does not decrease dramatically as counts increase above 30 m tex. The difference in yarn price from a count of 40 m tex to 30 m tex is less than 5%. Getting a shift of this magnitude would be significant and hence a more modest price gain, as assumed, is more likely. Second, the difference between the Cotlook A and Cotlook B index[27] is not that great, ranging form 10% in the early 2000s to less than 2% in 1996/97. Again, it is unlikely that breeding efforts could result in a shift in

33 This assumption was made for the CRDC investment in soils R&D and was based on long term ABARE forecasts.

fineness of the magnitude given by the difference in cottons under the Cotlook A & B indices, at least in the short to medium term. Hence the assumed price gain of around 1% would appear reasonable.

Economic benefits might also be generated as a result of royalties earned on equipment sales. Although the equity in the technology needs to be determined, it is assumed in this study that cotton growers would receive around 50%. This would represent a direct economic gain to them. The remainder of the royalty income would accrue to public Australian R&D agencies – largely CSIRO. Economic benefits are reported in Table 11, and are largely generated as a result of producing finer cotton.

Table 11: Economic Benefits: $m

Year	Levy Payers		Australia
	Finer Cotton	Royalty	
2016	$10.4	$0.25	$0.25
2017	$10.4	$0.25	$0.25
2018	$10.4	$0.25	$0.25
2019	$10.4	$0.56	$0.56
2020	$10.4	$0.56	$0.56
2021	$10.4	$0.56	$0.56
2022 - 2028		$0.56	$0.56

Social

The main social benefit from CRDCs investment in objective measurement technologies has been to place Australia at the forefront of change in this area. Apart from enhancing Australia's reputation for R&D, the developed scientific expertise will place the Australian cotton industry at a competitive advantage in terms of possible future developments relating to the exploitation of a more objectively based classification system for cotton globally.

The final area where social benefits are likely to be realised is in the flow-on impacts to the wider community following increased cotton production. Increased cotton production will occur in response to the additional profits generated from higher prices received for cotton. BDA Group (2004[34]) estimated that every additional dollar in added profitability on cotton farms would lead to an increase in cotton production valued at 80 cents. This increase in production would have and impact in regional economies in terms of additional demand for goods and services as well increase demand for labour. These benefits are reported in the following section.

34 BDA Group 2004 evaluation of Australian Cotton CRC outcomes.

5.5 Financial Sustainability Measures

Financial sustainability measures derived included the net present value (NPV), benefit cost ratio (BCR) and internal rate of return (IRR) on CRDC's investment. A discount rate of 5% was used and all dollar values were converted to 2008 dollars using the consumer price index. A summary of investment costs and benefits is provided in Table 12. Benefits have not been adjusted for investment risk..

Table 12: Program Costs and Benefits: $'000

Year	CRDC Costs		Levy Payers	Australian Community Benefits		
	Levy	Matching	Benefits	Royalty	Flow-on	Employment
1998	$17	$17				
1999						
2000	$48	$48				
2001	$102	$102				
2002	$82	$82				
2003	$108	$108				
2004	$124	$124				
2005	$164	$164				
2006	$153	$153				
2007	$144	$144				
2008	$102	$102				
2009	$203	$203				
2010	$203	$203				
2016			$10,669	$240	$3,174	$408
2017			$10,669	$240	$3,174	$408
2018			$10,669	$240	$3,174	$408
2019			$11,007	$578	$3,174	$408
2020			$11,007	$578	$3,174	$408
2021			$11,007	$578	$3,174	$408
2022-28			$578	$578		

Note: Costs are presented in current dollars.

Levy Payers

Financial sustainability measures were derived first for levy payers. Relevant costs include payments made by growers via the output levy on cotton production and relevant benefits include only those gains to cotton growers. Financial sustainability measures are reported in the table below along with a breakdown by benefits realised to date and by 5, 10 and 20 years from now. Reported measures are expected benefits as they have been adjusted for investment risk (50%).

The payoff to levy payers was estimated at $11m in net present value terms. The low IRR reflects the long time period over which benefits will be realised. The low pay off to date reflects the fact that benefits are not expected to be realised until 2016.

TABLE 13: FINANCIAL SUSTAINABILITY MEASURES: RETURNS TO LEVY PAYERS

Measure	To date	5 years out	10 years out	20 years out
PVB	$0m	$0m	$8m	$11m
PVC	$1m	$1m	$1m	$1m
NPV	-$1m	-$1m	$7m	$10m
BCR	0	0	8	12
IRR	na	26%	32%	32%

Note: PVB is the present value of benefits and PVC is the present value of costs

Australian Community

The second segment for which financial sustainability measures were derived was the Australian community at large. Relevant costs include payments made from matching funds received by the CRDC and relevant benefits exclude gains to cotton growers. Financial sustainability measures are reported in TABLE 14. The estimated pay off on the government investment was estimated at $5m in net present value terms. . Reported measures are expected benefits as they have been adjusted for investment risk (50%).

TABLE 14: FINANCIAL SUSTAINABILITY MEASURES: RETURNS TO AUSTRALIA

Measure	To date	5 years out	10 years out	20 years out
PVB	$0m	$0m	$3m	$6m
PVC	$1m	$1m	$1m	$1m
NPV	-$1m	-$1m	$2m	$5m
BCR	0	0	3	6
IRR	na	16%	23%	23%

Note: PVB is the present value of benefits and PVC is the present value of costs

5.6 Conclusion and Sensitivity Analysis

The payoff from CRDC's investment in the Fibre Classification R&D program was estimated at $10m in net present value terms. The two main factors driving investment benefits will be the risk associated with getting the technology taken up across the industry (and hence the achievement of price premiums on finer, mature cotton) and the magnitude of the price premium earned. To test the robustness of the assumed risk (50%) and premium ($35 per bale on 10% of production) assumptions sensitivity analysis was carried out on these variables. Results are presented in the table below.

Table 15: Sensitivity Analysis: NPV $m

Risk	Premium per Bale					
	$10	**$20**	**$30**	**$40**	**$50**	**$100**
10%	$1	$1	$2	$3	$3	$6
20%	$1	$3	$4	$5	$6	$13
30%	$2	$4	$6	$8	$9	$19
40%	$3	$5	$8	$10	$13	$25
50%	$3	$6	$9	$13	$16	$31
75%	$5	$9	$14	$19	$24	$47

The estimated payoff to levy payers was not found to be overly sensitive to the assumed premium earned and risk faced. Although higher premiums and lower risk increase the return, because the benefits are not realised for some time the impact on returns is more marginal. Likewise, the return would still be positive under more modest assumptions, with the investment breaking even at premiums of less than $10 per bale and a level of risk of 20% and less.