



An Economic Analysis of GRDC Investment in Farming Systems in the Northern Region



GRDC Impact Assessment Report Series:

Title: An Economic Analysis of GRDC Investment in Farming Systems in the Northern Region

April 2009

GRDC Project Code: ATR00005

This report was commissioned and published by the GRDC. Enquiries should be addressed to:

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ISBN No. 978-1-875477-96-2

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Impact Assessment: An Economic Analysis of the GRDC Investment in Farming Systems in the Northern Region

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Summary

This report evaluates the impacts of 18 Farming Systems projects in the GRDC Northern Region that ran over varying periods since 1996. The projects helped pioneer a re-interpretation and repositioning of research and extension characterised by a greater emphasis on a participatory approach; one that could better define those issues that warranted a farming systems perspective. Action learning and on-farm research were key aspects of the process. Many of the issues were enhancements to conservation cropping, and thus building on the momentum developed during the 1990s.

The GRDC investment in the projects was of the order of \$20 million. Partners in the projects, primarily State Departments of agriculture and natural resource management contributed \$52 million. A feature of many of the projects was GRDC support directly to incorporated farmer groups so that they could plan and manage research and contract other agencies to conduct research.

The investment is expected to deliver returns of over \$400 million dollars in the years to 2008 and over the next 25 years resulting in a benefit-cost ratio of the order of five to one. Benefits were reduced by the exceptional drought experience over the period of initial adoption of outputs. Wheat production in the six years to 2007 was 30% down on the six years to 2001.

The projects were concentrated in six sub-regions from Central Queensland to Central West NSW. As research issues were based on a participatory approach, there was a wide range of issues and practice changes that generally came under enhancements in the following categories:

- Tillage and Controlled Traffic;
- More flexible seasonal management of crop agronomy; and
- Rotations to include more break crops, pulses and to some extent, pasture leys.

The projects made some major contributions to improved productivity. Within the GRDC Northern Region, the drought impacts were least severe in the sub-region Northern NSW where over the last 15 years sorghum yields have increased by an average 3% pa and the area of chickpeas has increased from 25,000 ha to over 200,000 ha. Increased adoption of the practices targeted would have made further contributions to more sustainable farming, building on the increases in soil cover over the last two decades. The additional monetary benefits from reduced erosion and soil loss were not evaluated.

The projects recognised that built-in evaluation had a key role in project planning and management. There can be a high level of confidence in this evaluation to the extent that the project evaluations developed information more relevant at a sub-regional level rather than for farmer groups. Group data showed rapid adoption of many practices, but the regional rates were generally lower and with increased uncertainty on attribution

The Farming Systems theme with its emphasis on a participatory approach and action learning clearly generated a high degree of initial enthusiasm from graingrowers and researchers. Whether the approach led to success was shown by one project reviewing the group learning process to depend on the topic and on skilled facilitators able to manage the increased group diversity needed for sustained and successful outcomes.

1.Introduction

This report evaluates the impacts of investments by GRDC in 18 Farming Systems projects in the GRDC Northern Region. The projects have varying duration spanning parts of the period from 1996 to 2010. Benefits from outputs up to mid-2008 are included in this evaluation. The GRDC investment in the projects to 2008 totalled \$20 million in a total investment of about \$72 million over the same period.

The grain industry in the Northern Region is concentrated in Northern NSW and Southern and Central Queensland. The projects covered also include three in Central Western NSW, which has some characteristics more typical of southern Australia. The area of grain crops in the sub-regions covered by the projects averages about a quarter of the Australian total.

The main features that differentiate cropping in the Northern Region are:

- An increasing proportion of summer rainfall towards the north;
- High and probably increasing rainfall variability and intensity;
- High inherent but now declining soil fertility, and declining grain protein;
- Summer and winter cropping generally dependent on soils with high water holding capacity;
- Increased variability of seasonal production posing greater challenges for risk management;
- Cropping patterns dominated by cereals with little opportunity for a pasture phase; and
- Potential to meet the expanding market for feed grains.

By the mid-1990s GRDC was investing in major FS (farming systems) projects in NW NSW and SW Qld. Also at that time there was recognition in both the then Sustainable Rotations and Soil and Water Management Subprograms of the need for a more integrated approach (GRDC 1995). The Sustainable Rotations Subprogram placed priority on sustainable FS to improve soil fertility. The subprogram had previously given priority to grain legume improvement. The Soil and Water Subprogram also emphasised fertility issues in the context of stubble management and the need for research to increase involvement of industry and graingrowers, together with a greater emphasis on economic aspects. Drivers of this broader focus included a review of nitrogen research and recognition by growers that declining fertility was top priority.

An FS approach was also a catalyst for GRDC to trial alternative approaches to involving graingrowing more actively in research planning and management. During the 1990s there had been attempts to shift away from GRDC research based on small projects from traditional research providers to larger integrated projects contracted by GRDC. The particular emphasis of the integration varied depending on whether the emphasis was on integrating research and extension, or activities of research agencies. For FS projects, GRDC contracts were increasingly with incorporated bodies with a charter so that graingrowers could lead and manage research and extension in an integrated way. The potential for increased accountability for research levies was clear. Although there were inevitable teething problems, the new organisational forms and evolving roles eventually reflected and contributed to the changing functions of graingrowers, advisers and research agencies.

Following the reviews by GRDC in the mid 1990s, further major FS projects were funded in CW NSW and the eastern part of the Northern Region. The projects in the sub-regions have had further phases. In addition there have been smaller

support and linking projects. The geographic definitions have also evolved over the period since the mid 1990s. Early projects were based on biogeographical regions resulting for example in the northeastern part of NSW being combined with southeastern Qld. Subsequent projects have tended to operate more east west recognising institutional and border realities.

During the 1990s the increasing emphasis in the community generally on the environment and on ecologically sustainable development gave rise to a range of national programs with priorities that were aligned to some extent with those of the GRDC FS projects. The national programs included Landcare, the Natural Heritage Trust, and the National Dryland Salinity Program. There were also potential synergies with collaborative programs developed by the Rural R&D Corporations, for example the Managing Climate Variability Program and Grain and Graze.

There were other factors that contributed to the recognition that a strengthened farming system focus was needed for further progress in developing sustainable grain production. Off-farm aspects were taking into account much broader impacts than local soil erosion. For example, farming in CQ had to manage potential catchment impacts from farm run-off on the Barrier Reef. Research institutions were also adapting to trends in the industry, for example by:

- Decentralising research responding to the expansion and relocation of production, resulting in a shift away from research facilities located in the east of the Northern Region; and
- Increasing capacity in understanding risk management issues facing grain farmers, as exemplified in the formation of APSRU (the Agricultural Production Systems Research Unit) to combine the skills of the then QDPI and CSIRO in simulation modelling for managing production and environmental risks. A current product, APSFARM, a whole farm simulation model, is being used to inform and evaluate research in the CQ and other FS projects, and to enable some generality to be applied to results for specific sites and seasons.

The Northern FS projects were able to build on the evolving skill in the Northern Region on the use of simulation models to better understand the value of seasonal forecasting. All the most severe Australian wheat industry droughts have been associated with El Niño events. The El Niño impacts are particularly pronounced in the Northern Region (White 2000).

The farming systems label as it has evolved can clearly apply to a wide range of projects informed to varying and perhaps a convenient extent by a systems viewpoint. In the GRDC context, the projects in this evaluation had a number of distinguishing and challenging features as were later consolidated in a working FS definition for the Sustainable Rotations subprogram (GRDC 2000). FS projects were seen to be characterised by:

- Integrating the 'whole of system' consequences of component research, genotypes, new technology, alternative management strategies and agronomic practices;
- Integrating economic analysis, environmental aspects and farmer experience to define best practice;
- Including all stakeholders to consider economic, environmental and social consequences; and
- Involving farmers and other stakeholders in participatory on-farm research and action learning.

In the last decade the four aspirations as articulated could have been seen as simply the inevitable attributes of a genuinely participatory approach to achieving sustainable outcomes. The consensus that appears to have evolved on the focus

of FS research in the grain industry is that it is inherently participatory, and therefore as much about process as content, and more about capacity building than simply technology transfer.

Three implications for this evaluation are:

- The participation of a broader range of stakeholders should generally lead to legitimate diverse economic and environmental objectives;
- Research agendas will include a diversity of topics that are difficult to specify in advance, and
- Evaluation will be challenging because of the diversity of approaches and difficulties in attributing outcomes to outputs.

Greater prominence to environmental objectives may require some modifications to how the attitudes of stakeholders are determined. For example Greiner et al (2009) showed from a survey of graziers in the Burdekin catchment that environmental programs would need a better understanding of the motivations and risk attitudes of farmers.

The scope to improve the profitability and sustainability of Northern grain farms has been demonstrated by Wylie (2008). Ten practices with proven potential are listed in his analysis of high profit farming but only about one half of graingrowers have adopted some of the practices.

2. Project Investment

Most FS projects in this evaluation were initially part of GRDC Objective 3 – Protecting and Enhancing the Environment. The Performance Indicators included proportions of farmers adopting Minimum Tillage or Direct Drill. More recent projects are part of the Practices Line of Business and the Performance Indicators have changed to various indicators of adoption of Precision Agriculture.

The Northern FS projects contribute primarily to the first two of the three categories in the GRDC objective for Output Group 2 Practices (GRDC 2007):

- Develop and validate better farming practices and have them adopted faster; and
- Develop sustainable farming systems adapted to each of the industry's agroecological regions that are responsive to grower, community and catchment needs.

The projects are listed in Table 1. The duration of each project is included. This evaluation includes only outputs achieved by 30 June 2008. The evaluation thus excluded some projects that begun in 2007 and 2008 where there were no significant outputs in terms of impacts or likely potential impacts in the next few years. There were also some FS projects that began in the mid 1990s or later that were not included.

The projects are listed in an order based on sub-regions starting with Central Queensland and then Southern Queensland through to Northern NSW and finally Central West NSW. The allocation is only approximate because some of the earlier projects were defined by agro-ecological regions whereas more recent projects have been more flexible.

Table 1: Details of the Northern Farming Systems Projects

Code	Title	Lead Organisation/ Principal Investigator	Start	Finish
DAQ382	Sustainable farming systems for Central Queensland (Phase 1)	QDPI - John Doughton	1/07/1996	30/06/2002
DAQ00049	Sustainable Farming Systems for Central Queensland (Phase 2)	QDPI - John Doughton	1/07/2002	30/06/2007
DAQ00068	Networking Innovation in Grower Groups	QDPI - Michael Cahill	1/01/2004	31/12/2006
DAQ00116	Central Queensland Sustainable Farming Systems (Phase 3)	QDPI - Richard Routley	30/06/2007	30/06/2010
CSC41	Sustainable farming systems for the north-eastern grain belt	CSIRO - Peter Carberry	1/07/1997	30/06/2002
DAQ403	Developing best research/extension practice through evaluation of process and impact	QDPI - David Lawrence	1/07/1997	30/06/2002
DAQ471	Developing more sustainable farming systems for broadacre, rainfed cropping on Ferrosols	QDPI - Michael Bell	1/07/1999	30/06/2003
DAQ00050	Eastern Farming Systems (Phase II) - a partnership for participatory RDE in the north eastern grain belt	QDPI - David Lawrence	1/07/2002	30/06/2007
DAN459	Western Farming Systems Project	NSW Agriculture - David Mitchell	1/11/2000	31/12/2004
SORC1	Western Farming Systems Research - on-farm research	Special One Research Company	1/9/2000	30/06/2004
DAQ499	Sustainable farming systems for the marginal cropping areas of SW Qld	QDPI - Richard Routley	1/07/2000	30/06/2005
UWS28	Western Farming Systems Project: On-farm research	UWS - Peter Cornish	1/02/2001	1/10/2004
NGA00001	Validation and integration of new technology through grower groups in north-west NSW and south-west Queensland grain growing zones	NGA - Greg Rummery	1/07/2005	1/07/2010
DAQ00103	Validation and integration of new technology through grower groups in south-west Queensland	QDPI - Nicholas Christodoulou	1/07/2005	31/12/2006
NGA00002	Validation and integration of new technologies and production systems in the north east NSW grain growing region -North East Farming Systems	NGA - Richard Daniel	1/07/2007	30/06/2010
CWF1	Central West farming systems – farmers advancing research	CWFS - Bruce Watt	1/07/1998	30/06/2003
CWF00002	Central West Farming Systems - Farmers Advancing Research	CWFS - Catherine Evans	1/07/2003	30/06/2005
CWF00007	Central West Farming Systems - Extension and Development	CWFS - Graham Mc Donald	1/07/2005	30/06/2008

Source: GRDC Project Proposals. Note the CSC41 project was actually a conglomerate of three projects led by CSIRO including Qld DPI, Qld NRM and NSW Agriculture.

The investments are listed by project in Table 2.

Table 2: Project Expenditure (\$)

Project	GRDC	Other
DAQ382	3,122,479	15,920,781
DAQ00049	2,672,121	5,633,602
DAQ00068	296,043	498,950
DAQ00116	800,000	3,382,000
CSC41	2,397,000	8,205,000
DAQ403	214,438	637,782
DAQ471	508,899	1,887,954
DAQ00050	2,654,578	4,998,913
DAN459	643,872	1,015,040
SORC1	568,054	270,000
DAQ499	1,876,863	5,110,821
UWS28	459,150	643,872
NGA00001	866,925	753,200
DAQ00103	382,070	1,005,490
NGA00002	297,173	288,500
CWF1	659,866	1,095,871
CWF00002	610,732	494,874
CWF00007	927,545	589,700
Total	19,957,808	52,432,350

Source: GRDC Project Proposals and Final Reports

For the eighteen projects funded over the period since 1996/1997 GRDC has invested a little over a quarter or 27.6% per cent of total resources in nominal terms, or almost \$20 million with the remaining support of \$52.4 million provided by the host organisations. **Note** the host organisation contributions are as submitted in project proposals rather than amounts actually acquitted.

The total investment by GRDC and partner organisations amounted to \$72.4 million over the years ending June 1997 to 2008. The major partner organisations were the NSW and Queensland agriculture and natural resource

agencies. Some projects included CSIRO and one included the University of Western Sydney. In NSW there were several projects where GRDC directly funded incorporated bodies representing farmer groups.

Table 3: Annual Expenditure for the Projects

Year (to 30 June)	GRDC (\$)	Other (\$)	Total (\$)
1997	411,476	2,865,905	3,277,381
1998	1,197,877	4,835,266	6,033,143
1999	1,367,947	5,160,952	6,528,899
2000	1,407,263	5,913,324	7,320,587
2001	2,180,312	7,077,737	9,258,049
2002	1,581,415	3,705,847	5,287,262
2003	2,220,719	4,509,725	6,730,444
2004	2,370,231	4,076,651	6,446,882
2005	2,031,644	3,688,744	5,720,388
2006	2,065,611	3,308,068	5,373,679
2007	2,179,580	4,854,631	7,034,211
2008	943,733	2,435,500	3,379,233
Total	19,957,808	52,432,350	72,390,158

Source: GRDC Project Proposals and Final Reports

3. Project Activities and Outputs

The principal outputs from the investment made over the 12 year period to 2007/2008 are listed in Table 4.

Table 4: Outputs Achieved by the Project Investments

Project Code	Project Outputs Achieved
DAQ382	<ul style="list-style-type: none"> • New and existing technology integrated in developing sustainable farming system options for central Queensland. • Organised teams of farmers, scientists and agribusiness to develop new and existing technology on farms ensuring increased commercial acceptance and adoption.
DAQ00049	<ul style="list-style-type: none"> • Integrated new and existing technology in developing sustainable farming system options for central Queensland. • Developed teams of farmers, scientists and agribusiness to further develop new and existing technology on farms to ensure commercial acceptance and adoption.

DAQ00068	<ul style="list-style-type: none"> • A coordinated network of grower groups established, coordinated and maintained for the Queensland grains industry. • Self-managed group activities planned and conducted. • Group outcomes, process and evaluation, published and circulated.
DAQ00116	<ul style="list-style-type: none"> • Knowledge and understanding of the current and potential economic, environmental and social performance of CQ grain and mixed farming businesses and the sensitivity of this performance to a range of environmental and management factors. • New and refined practices, technologies and management strategies that have the potential to improve the economic, environmental and social performance of CQ grain and mixed farming businesses.
CSC41	<ul style="list-style-type: none"> • Enhanced scientific knowledge of the functioning of agricultural systems attained through undertaking 10 participatory on-farm research trials involving farmers, agribusiness and researchers. • Five action-learning programs developed and implemented that have contributed to improved skills and confidence of farmers and agribusiness in managing complex farming systems.
DAQ403	<ul style="list-style-type: none"> • Evaluations of action learning and on-farm research in CSC41.
DAQ471	<ul style="list-style-type: none"> • Benchmarks and decision support aids for sustainable cropping. • A sustainable cropping system developed for Ferrosols.
DAQ00050	<ul style="list-style-type: none"> • Priority 'Farming Systems' themes for the project identified through a partnership of the project team, farmers and agribusiness. • Greater participant understanding and insights developed from participatory on-farm research on priority farming systems themes identified in the project.
DAN459	<ul style="list-style-type: none"> • Completed crop/pasture rotation sequences at two sites to identify constraints to profitable and sustainable crop production in the WFS zone. • Identified research and extension priorities. • Development of a draft 'Best Practice Guide'.
SORC1	<ul style="list-style-type: none"> • An annual results summary based on research on priorities. • A Best Practice Guide. • Evaluation of Impacts.
DAQ499	<ul style="list-style-type: none"> • The development of tools and processes to support decision making on the strategic and tactical management of soil nutrition, water and crop and pasture rotations.
UWS28	<ul style="list-style-type: none"> • Contributed to prioritising constraints of current farming systems. • Provided results and advice to SORC project for Best Practice Guide. • Contributed to evaluation.
NGA00001	<ul style="list-style-type: none"> • Developed the Northern Grower Alliance in the south western portion of the northern grains region to deliver all project outputs. • Delivery of an annual summary of validated and integrated technology trial

	<p>results to all NGA stakeholders.</p> <ul style="list-style-type: none"> • Monitoring and evaluation of the level of adoption and change across the target area.
DAQ00103	<ul style="list-style-type: none"> • An annual results summary detailed new information and knowledge on new and existing technologies and management practices, especially in the key theme areas of: <ul style="list-style-type: none"> a. Climate risk management and systems WUE b. Application of precision agriculture technologies c. Maintenance and improvement of soil fertility and water quality • A series of group meetings, field days, workshops and advisor updates. • Communication and Information products.
NGA00002	<ul style="list-style-type: none"> • Developed a cohesive and collaborative NGA/ NSW DPI model, in the south-eastern portion of the northern grains region. • Delivery of an annual summary of validated and integrated technology trial results to all NGA stakeholders. • Monitoring and evaluation of adoption and change in farming systems across the target area.
CWF1	<ul style="list-style-type: none"> • Results including sustainability indicators from the core site and seven satellite sites published in an annual handbook.
CWF00002	<ul style="list-style-type: none"> • Regional atlas for general reference. • Annual communication agenda and Research Compendium. • District Best Practice Guide.
CWF00007	<ul style="list-style-type: none"> • Continual communication and extension information distributed throughout the year. • Annual communication agenda and Research Compendium. • Annual series of field days, seminars and workshops.

Source: GRDC Final Reports

4.Outcomes

Table 5: Summary of Principal Outcomes for the Farming Systems Projects.

Sub-Region	Principal Outcomes
CQ	<ul style="list-style-type: none"> • By 2007, the adoption of practices clearly linked to profitability increased by an average of 13% from the 2002 level. • Dramatic increase in the areas of Butterfly Pea, a legume well suited to heavy clay soils where fertility has declined. • Improved understanding of the drivers of profitability and sustainability and of the practice changes to achieve them, including the possibly higher risk and lower profit from a ley pasture component in a crop rotation. • Recognition of the value of participatory approaches and action learning in accelerating adoption and building capacity of industry stakeholders. • Reduced environmental impacts from improved guidelines for atrazine management, and from simplifying Controlled Traffic layouts by showing alignment with slope was not critical.
SEQ-NE NSW	<ul style="list-style-type: none"> • For the final phase of the Eastern FS project, increased understanding and adoption by farmers and agronomists of practices needed to achieve sustainable management of the soil resource by knowledge of sub-soil constraints and using crop rotations and RDE processes. • Built the capacity to develop and use action learning processes, and provided best practice guidelines for on-farm research.
SWQ-NW NSW	<ul style="list-style-type: none"> • Increased adoption by supporting growers and advisers in developing new or modified systems that would ensure the successful adoption of reduced tillage systems. • From 2000 to 2005 the SWQ project doubled areas under Zero Till and areas with nitrogen fertiliser. • The Northern NSW project increased adoption of chickpeas by showing the value of a rotational system and reduced tillage in increasing sustainability and reducing risk. • High level of adoption of stripe rust recommendations based on on-farm research, and validation of demonstrated value of improved linkages between R&D agencies, growers, advisers and agribusiness.
CW NSW	<ul style="list-style-type: none"> • Developing and maintaining farmer involvement in research, despite an extreme drought sequence, by developing 10 regional sites using participatory action research. • A survey showed 71% of farmers implemented findings from the research. Increased use of N and P following local demonstrations of value in the CW.

5. Benefits

Overview of Benefits

This evaluation of readily quantifiable benefits concentrates on the technological outputs leading more directly to farmer outcomes. The benefits in terms of capacity building are not quantified in this analysis. The qualitative social benefits listed in the Table below are based in particular on survey information for CQ (Shepherd and Routley, 2008).

An overview of benefits in a triple bottom line categorisation is shown in Table 6.

Table 6: Categories of Benefits

<p><u>Industry Productivity and Profitability</u></p> <p>Short term</p> <ul style="list-style-type: none"> • Improved profitability from monitoring of soil water and nitrogen • Yield improvements including in drier years from reduced tillage and improved stubble management. • Increased use of more profitable rotations including pulse crops. • Improved access by growers to locally relevant information through Best Management Practice manuals and annual research summaries. <p>Long term</p> <ul style="list-style-type: none"> • Higher more sustainable yields from reduced soil loss, improved soil structure and higher organic carbon soil content. • Cropping systems better adapted to climate variability and change.
<p><u>Environmental</u></p> <ul style="list-style-type: none"> • Reduction in soil loss due to water erosion resulting from the widespread adoption of reduced tillage, controlled traffic, and opportunity cropping. • Reduction in deep drainage from the adoption of opportunity cropping. • Reduced off-site movement of herbicides and pesticides, in particular atrazine (less contamination of surface and ground water) • Less soil fertility rundown and decreased off-site loss of nutrients • Enhanced soil biological activity and higher level of soil organic matter.
<p><u>Social</u></p> <ul style="list-style-type: none"> • Increased industry, community, and research capacity. • Increased ownership by graingrowers of approaches to resolving local concerns through action learning and independent decision-making. • More effective social networks from grower groups and local demonstrations of Best Management Practices.

Public versus Private Benefits

The benefits identified from the investment are predominantly private benefits, namely benefits to grain producers in the GRDC Northern Region. There also will have been some public benefits produced, mainly environmental in nature including reduced losses of sediments and improved control of off-site impacts from fertilisers, pesticides and herbicides.

Additionality

If GRDC had not supported this program, only a low level of support would have continued or emerged for a comprehensive regional FS strategy underpinned by a participatory approach. The alternative for GRDC and one that maintained regional equity in terms of funding, would most likely have been to continue to

fund a large number of smaller projects addressing more specific issues, some of which would have been candidates for a FS approach. For that scenario, adoption would have continued but at a reduced rate. Much of the research done in the FS projects was essentially adaptation of existing practices. For a scenario with no government contribution to GRDC, it is highly unlikely that GRDC would have taken on such a large ambitious program. Therefore less progress and slower progress would have been made.

Distribution of Benefits along the Grains Supply Chain

Some of the potential benefits from higher average yields and more consistent annual grain supply will be passed along the supply chain to grain processors, and other users of grain including intensive animal producers and ultimately consumers. However in other than drought years a high proportion of grain is exported, so that benefits will be captured in the main by Northern grain producers. In the longer term conservation agriculture based on reduced tillage could have significant benefits as a point of differentiation of grain markets where certification of good agricultural practice is becoming increasingly important.

Benefits to Other Primary Industries

The action learning and on-farm research processes have been widely publicised in other regions and industries. That may have led to greater confidence in their adoption. The wool and beef grazing industries in the Northern Region would also have had some direct benefits from adoption of some FS practices on mixed farms. Most of the FS projects had an objective relating to expanding ley farming based on beliefs that it was necessary to have a ley rotation to achieve a sustainable system. The general impression was that the objective was not achieved except on a small scale.

Match with National Priorities

The Australian Government's national and Rural R&D priorities are reproduced in Table 7.

Table 7: National and Rural R&D Research Priorities 2007-08

Australian Government Priorities	
National Research	Rural Research
<ol style="list-style-type: none"> 1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia 	<ol style="list-style-type: none"> 1. Productivity and adding value 2. Supply chain and markets 3. Natural resource management 4. Climate variability and climate change 5. Biosecurity <p><i>Supporting the priorities:</i></p> <ol style="list-style-type: none"> 1. Innovation skills 2. Technology

The investment in the projects was predominantly focused on National Research Priority 1. The investment was focussed on Rural Research Priorities 1, 3 and 4.

6. Pathway to Adoption

The FS projects were implemented in close association with graingrowers. Action learning via groups using a participatory approach was a dominant theme of most projects. The diversity of views of farmers and researchers was seen to be the catalyst to achieve more effective local research and subsequent adoption. But the challenge is increased if diversity makes effective participation harder to achieve. The implicit assumption was that those involved in the projects would have the mix of skills and the motivation to develop new approaches that would foster learning and adoption within project groups and more broadly.

Pannell et al (2006) have reviewed the extensive literature on adoption. The disappointing levels of adoption of conservation practices that are often observed were seen to be readily explicable in terms of the characteristics of:

- The learning process;
- The potential adopters; or
- The conservation practices.

The FS projects included a comprehensive evaluation of the processes involved by Lawrence (2006). The performance of groups in some of the FS projects was monitored to determine the important factors contributing to effective groups. His conclusions focussed on:

- Group diversity, effective participation using skilled facilitation as key factors in the level of learning achieved, and
- Evaluation as the fundamental and most powerful tool to strengthen participation and the ongoing development of shared objectives.

These FS conclusions are often seen to contrast with a Transfer of Technology approach with its simpler pathway to adoption, but recognising that a Transfer of Technology approach can be the most effective when appropriate.

The investment produced assembly and integration of existing information as well as generating new information from a considerable number of short term on-farm trials and to a lesser extent longer term experiments. Projects were usually under the management of local groups with representation of graingrowers and researchers. That process would have generated considerable ownership of information produced by graingrowers.

The CQ projects in particular adopted a systems approach to communication as an integral part of achieving practice change by using Bennett's Hierarchy (1975) as a planning and monitoring framework to close the loop. The hierarchy is illustrated in Table 8.

Table 8 Bennett's Hierarchy for Achieving End Results (Outcomes)

<i>Level</i>	<i>Link to lower level</i>
VII. End results.....	are achieved only if there is...
VI. Practice Change	which will occur if there is...
V. KASA change	as a result of peoples...
IV. Reactions	to their...
III. Involvement	in...
II. Activities	that are conducted using...
I. Resources	available to the project.

Features of the projects included the emphasis on monitoring, evaluation and communication activities via a wide range of mechanisms and media. Well attended field days, bus trips and field walks were most prominent as were newsletters, Best Practice booklets based on trial results and many other print media channels.

As an example, the following is a summary of five years of activity in the most recent CQ FS project:

- 500 'Cropping Central' quarterly newsletters distributed by mail and email
- 107 media releases
- 40 conference papers
- 35 Field Days and Workshops (additional to grower group meetings)
- 25 radio and TV interviews
- Action learning packages developed and delivered
- Action learning groups developing priorities and providing feedback
- 4 bus tours and field visits with school teachers and students

The Northern FS projects were major contributors to the First Australian Farming Systems Conference in Toowoomba (Doughton 2003). By that time GRDC were funding numerous projects under a Farming Systems banner. The CQ project members contributed 11 papers to the Conference.

The project SORC1 that was integrated with DAN459 included an evaluation survey of WFS activities following the completion of the projects. The survey included information on organisations contacted by wheat growers for a range of practices some of which were practices included in the WFS projects. The survey demonstrates the range of sources and the dependence of the source on the particular practice. Interpretation is complicated because the WFS included a NSW DPI component and generated information made widely available to other organisations. The issue of information source is also relevant to attribution as will be considered further in a later section on measuring benefits.

Table 9: Survey of Wheat Growers in Northern NSW Showing Contacts Made and Practices Changed.

Item	Western Farming Systems	Agronomist Adviser	NSW DPI	Total
Number of contacts by wheat growers with the organisations	46	56	110	222
Number who changed or implemented one or more practices following contact	13	25	35	83
<u>Practice Changed</u>				
Reduced Tillage	5	7	13	25
Crop Varieties / Type	2		11	13

Chemical / Herbicide Use	3	6	3	12
Generally Improved System	2	5		7
Machinery Differences / Incorporation	1	7	4	12
Crop Rotation	4	4	2	10
Moisture Conservation		2		2
Fertilisers			4	4

Source: Adapted from SORC1 project report.

The WFS projects showed much higher levels of adoption within groups than within the sub-region generally. That is a matter for concern for FS projects using groups to ensure more relevant research and more rapid adoption beyond the groups. The Central Queensland FS projects have had three phases and the opportunity to monitor adoption over a longer period. Results for two practices are shown in Table 10.

Table 10: Proportion of Central Queensland Farmers Adopting or Expecting to Adopt Practices from a 2001 Survey

Practice	1997	2001	2006 (expected)
<u>More than 2/3 area under Zero Till</u>			
Farmers in project Groups	14	76	88
Other farmers in CQ Region	8	30	47
<u>More than 2/3 area under Controlled Traffic</u>			
Farmers in project Groups	7	49	73
Other farmers in CQ Region	7	8	34

Source: Final Report DAQ 382 (Project Update No 16, Sept 2002)

The adoption trends for Zero Till and Controlled Traffic are clearly very rapid in the FS project groups at about double the rate in CQ generally. Answers to how much can be attributed to the FS projects will be ambiguous. For example, the Groups had a high initial uptake of Zero Till and there were other sources of information to encourage adoption. There were major projects on Controlled Traffic in CQ last decade and it is likely that could have contributed to the rapid increase, for example if the FS groups had common members or were in the same locality as existing Controlled Traffic activity. The following section takes into account the attribution aspects.

7. Measuring Benefits

The evaluation does not measure social or environmental benefits, or longer term benefits likely from the improved capacity developed by the projects. The only economic benefits identified that can be readily quantified are those relating to improved productivity from increased yields or changes in input costs.

The projects made extensive use of surveys of farmers in groups and in their sub-region generally, to monitor progress. Although the surveys may have been subject to an unknown degree of response bias and to lack of baseline control data to compare group members with non-members, the surveys generally showed high levels of practice change, support and enthusiasm for an FS approach. For example for DAN 459, a project beginning in 2000, a baseline survey conducted in 1999 showed that there were significant differences in rotations and tillage practices between growers affiliated with Western Farming Systems (WFS) from a previous FS project (one not in this evaluation) and those growers that were not. For example for WFS growers:

- 29% grew chickpeas in 1999 compared to 7% of non WFS growers; and
- 29% practiced no-tillage in 1999 compared to 13% of non WFS growers.

Clearly WFS farmers in the groups for DAN459 would have had a head start. Traditionally the relatively easily measured increases in crop yields from new varieties have dominated perceptions of the sources of improvements in productivity and profitability. An analysis by Black et al (2008) puts other sources of productivity gain into perspective, or at least raises questions about priorities for investment. Their analysis of long term trends in wheat yields in South Australia showed that contributions from varietal gain were less than half those from the combination of improvements in FS and the interactions of FS improvements with varietal gain. Overall gains in productivity averaged 1.7% pa, a figure that could be regarded as typical of productivity gains achievable in regional assessments.

A possibly inherent feature of FS research (perhaps in contrast with research on improved varieties) is the potential for a large number of outputs each addressing what farmers in particular have identified at a point in time as a local or general problem or opportunity. Overlaid on farmer priorities for R&D are researcher views on their capacities and incentives. The CQ project DAQ00049 is just one example; there were 30 contracted outputs. The project included 39 practices where change was targeted. Many have led to economic benefits. For the CQ project, there are benefits demonstrated from increased adoption of improved practices relating for example to:

- Reduced tillage
- Crop nutrition
- Water use efficiency
- Crop rotations and agronomy
- A ley pasture phase
- Weed and disease management, and
- Precision agriculture including farm layout and Controlled Traffic.

Each practice will have varying levels of benefit and adoption rates that can be attributed to the CQ projects. Each of the Northern FS projects had a generally similar list of benefits from practice change but to a varying degree in particular locations. Therefore the only feasible approach to measuring benefits is to aggregate. At an aggregate level, the practice changes can all be seen as contributions to more sustainable FS. Many of them are ongoing adaptations and

adjustments building on the fundamental driver of reducing tillage. As Strahan et al (2005) noted for project DAQ499 - *'The project played a significant role in developing management strategies to capitalise on the opportunities presented through reduced tillage. The project played a minor role in driving the initial adoption of reduced tillage but played a major role in providing research and extension for practices that made the implementation of reduced tillage practical and widely applicable to most farming systems in the area. The increased confidence provided through this RD&E supported the management system changes and encouraged the investment required to make the significant changes at the farm level.'*

Measures of reduced tillage include proportions using Zero-Till (ZT) or no-till, and also measures of the proportion of cropping area involved. The expansion in reduced tillage has been rapid in all cropping areas over the last two decades. The development of locally adapted machinery to handle stubble was the early catalyst. Later progress required an FS approach to develop solutions to nutrient, disease and weed control aspects of the change. As shown in Table 11 and in common with other GRDC regions, the proportion is still increasing in the Northern Region notwithstanding major drought impacts. The lower proportion in the Central West reflects the different nature of the farming system with a greater reliance on a pasture phase and difficulties in evolving to a no-till system that growers would see as affordable and low risk. There is however still a high level of interest in adoption. For example a field day at Condobolin attracted an attendance of 750 in 2008.

Table 11: Proportion (%) of Respondents who Have Used, Currently Use and are Planning to Use No-till

Region	Used no-till prior to 2004	Using no-till in 2008	Have used no-till
NSW Central West	56	62	72
NSW Northern	79	82	90
QLD Southern	78	82	85

Source Llewellyn et al (2008)

The FS projects had a strong focus on monitoring and evaluation through surveys of adoption and cost benefit analyses at the conclusion of the projects. There has however been no follow-up monitoring after the projects are completed. The analyses were typically based on farm budgets comparing a current conventional tillage and crop rotation system with an interpretation of an enhanced one resulting from the FS projects. The basis for the benefit was generally a yield increase, an additional crop or a higher value crop in the context of a rotation. The increased extent of reduced tillage will therefore only be a partial indicator of the benefits of the FS projects. As shown above, the projects developed a wide range of practices to further capitalise on the benefits of reduced tillage.

There is a long history of research in the GRDC Northern Region on the benefits of reduced tillage. The overwhelming benefit has been the extraordinary reduction in soil loss where adequate cover is maintained. Thomas et al (2007) have reviewed the Queensland research and concluded that results were generally consistent with similar research in northern NSW. Results are:

- Greater gain (13%) in soil water storage over the fallow;
- Grain yield increases averaging 11% (but higher in lower yielding environments);

- Lower soil nitrate-N (24%) and grain protein content (6%); and
- Increased soil carbon.

Although fertiliser nitrogen or contributions from a legume component can be supplied to overcome reduced soil nitrogen from reduced tillage, nitrogen is a risky input for many sites and seasons in the Northern Region.

Further constraints on adoption were seen by Thomas et al to be:

- Farmer attitudes and aspirations;
- Machinery conversion or replacement costs;
- Buildup of soil and stubble-borne plant diseases;
- Use of residual herbicides that may limit crop options;
- Dual use of land for grazing and cropping;
- Herbicide resistance;
- Buildup of hard-to-kill weeds;
- The need for soil disturbance in some situations; and
- Concerns by farmers about the possible effects of herbicides on the environment and human health.

Many of the local manifestations of the above constraints were incorporated as challenges of one kind or another in the various FS projects. For example surveys of farmers often show that their major problems are related to managing weeds and diseases. What farmers see as a weed issue might be seen by a researcher to be an FS issue. For disease problems, traditional approaches might have emphasised breeding of resistant varieties whereas an FS context might emphasise rotations and opportunities to use break crops.

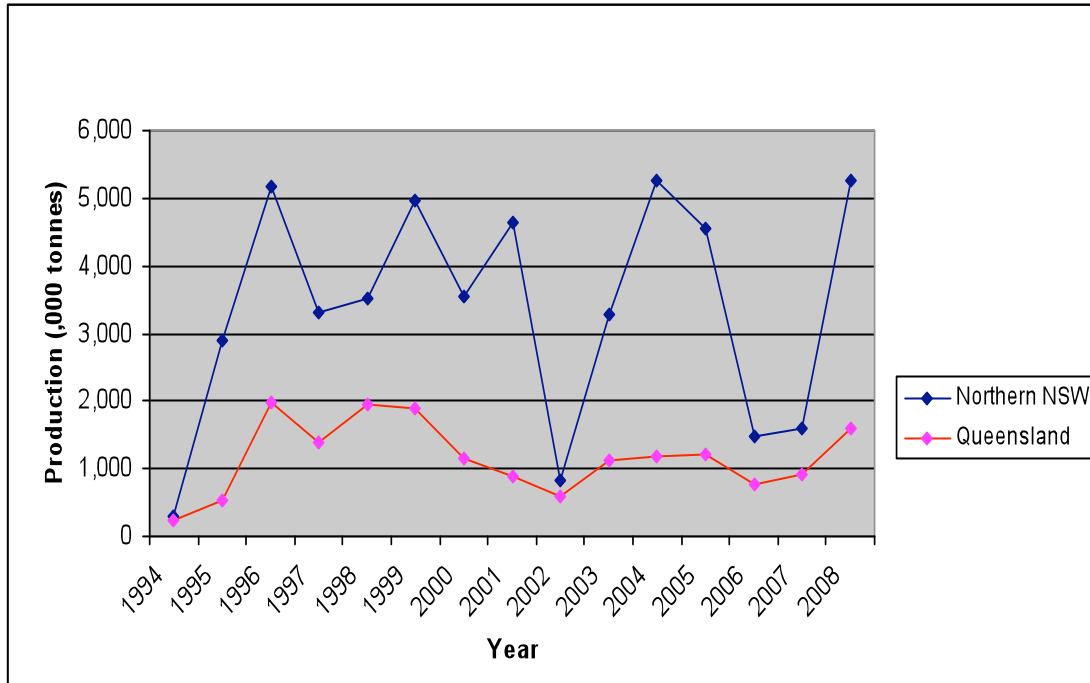
The evaluations included opportunities for additional crops and for rotations that had yield advantages additional to those from comparisons based on simple crop-fallow systems. In terms of additional crops, Berndt and White (1976) first showed the benefits from opportunity cropping in a pioneering simulation study using a simple crop water balance model. Growing a summer or winter crop when there was adequate soil water stored was shown to be superior to fixed winter or summer cropping on the Eastern Darling Downs. The superiority was reduced for a soil with higher water storage at Dalby. At Roma lower average rainfall was such that there was little advantage from opportunity cropping.

Adoption Patterns

The extreme rainfall variability experienced in the Northern Region over the last two decades has had a major impact on the success of the projects and the extent of on-farm research that could be done. Activity in some of the projects was severely limited particularly during the three years, 2002, 2006 and 2007 when droughts were widespread. Production in Northern NSW was more than halved in those three years. Assumptions on project benefits need to take the drought pattern in sub-regions into account. The two key factors are that for most practices, farmers with incomes virtually wiped out by low yields are reluctant or unable to change during and after a drought, and for many practices the benefit is a yield increase dependent on the season. Figure 1 shows wheat production since 1994. The recovery in the last decade was clearly less in Queensland than in Northern NSW.

Regional cropping patterns are potentially a key indicator of adoption patterns for the major project outcomes of more profitable and sustainable rotations. The usefulness of regional crop statistics is limited by the limited coverage of many statistical series and by the high degree of variability in seasons and prices.

Figure 1: Wheat Production in Northern New South Wales and Queensland, 1994-2008



Sources: for Queensland (ABARE 2008), for NSW based on NE, NW and SE sub-regions, NSW DPI.

As shown in Figure 2 for the decade to November 2006 the period analysed covers in an approximate way the period of more extreme drought in eastern Australia. (There have however been some significant dry periods since 2006). Rainfall in the north and south of the Northern Region was 'Very much below average', (in the lowest 10% of decades). In the Northern Region these would have had most influence in CW NSW. This contrasts with above average in much of the main cropping areas of Northern NSW which are based more on fallow moisture build-up. To some extent that would have balanced the specific drought years in Northern NSW. On the rainfall experience adoption could be expected to be most impacted in CQ and CW NSW. In CQ, fallow moisture storage and opportunity for catch-up summer or winter crops was also advantageous. Adoption of FS practices was therefore more likely to be seriously impacted in CW NSW particularly with dependence on winter cropping and sheep rather than cattle, and as there was an extreme run of drought years. The benefit estimates will take production variability into account.

Further analysis of the impacts of rainfall variability in the region have been undertaken by Kokic et al (2006) as part of an ABARE analysis for GRDC on productivity changes in the grain industry. Table 12 summarises the results for the Northern Region.

Figure 2: Australian Rainfall Deciles over the decade to November 2006

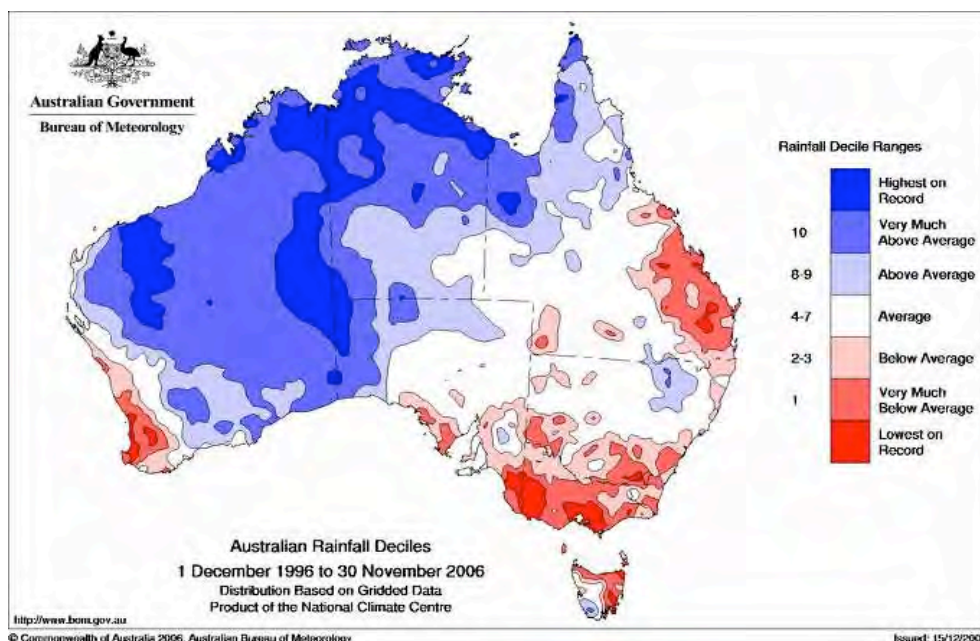


Table 12: Average Grain Farm Total Factor Productivity Growth Rates and Sensitivity to Moisture Availability for the Northern Region, 1988-89 to 2003-04

GRDC agroecological zone	Productivity Growth rate (excl. moisture effect)	Sensitivity to moisture availability
Central Queensland	0.68	0.96
NSW NE and Qld SE	1.70	0.49
NSW NW and Qld SW	3.30	1.47
Central NSW	1.06	0.90

Source Kocic et al (2006)

The productivity analysis included social, physical, natural, financial and human capital assets and found significant influences of all except social. The clear implication is that measures aiming to increase productivity need to go beyond simple economic measures including the simplest measures of increasing output by increasing yields. The focus on a broader range of assets should sit comfortably with a rigorous FS approach.

Significant contributors to productivity increases in the Northern Region included:

- The moisture availability index (actually a spring stress index for wheat and therefore a poor indicator for summer cropping);
- Land area and land use intensity;
- A proxy for availability of finance;
- Education of the operator;
- Crop specialisation;
- Off-farm investment income;
- Corporate farms; and
- A trend indicating importance of other factors not included in the model.

Other features of the analysis indicating large impacts on productivity relevant to estimating the FS benefits included:

- Productivity in all GRDC Regions has continued to decline, a trend at least in part related to the major droughts over the last two decades;
- The positive impacts from the use of direct drill but only in drier years in the Northern Region;
- Productivity in the Northern Region is more highly variable between farms;
- The high growth rate in NSW NE and Qld SW;
- Corporate farms in the Northern Region had 28% higher productivity growth; and
- The main source of productivity growth, in contrast with other GRDC Regions was not from increased outputs, but from reduced inputs other than chemicals.

Trends in outputs from increased yields would have been clouded over the period by the major drought impacts in many years. Although the spring moisture index used by ABARE accounted for some of the drought impacts, there were still large drops in productivity in the drought years after allowing for the moisture index component.

There are some important yield trends to be considered. Key aspects relevant to yield trends in the Northern Region were summarised by Stephens (2002):

- The best performing shires consistently increased N fertiliser application and crop diversity (pulses, oilseeds, or sorghum), with the latter being important where N-fixation, and/or soil cleansing of root diseases, was beneficial.
- Climate variability dominates regional cropping performance through its impact on yield variability and the level of risk associated with a high-input, high-yield, farming system.
- The application of N fertiliser and the adoption of pulses and oilseeds decreased as yield variability increased.
- Sorghum yields increased steeply in the 1990s in northern NSW as farmers increased nitrogen inputs.
- In Queensland risk related to high yield variability discourages increased fertiliser use.

In the Northern Region there are some good examples of outstanding sub-regional trends in yield and cropping patterns in the direction of more sustainable systems. These include in Northern NSW, based on comprehensive NSW DPI data and on Potgieter et al (2005) for sorghum yields:

- The rapid increase in sorghum yields, where over the last 15 years yields have increased from about 2.5 t/ha to an average close to 4 t/ha, and
- The expansion in the area of chickpeas from about 25,000 ha 15 years ago to over 200,000 ha in recent years.

Surveys in Central Queensland in 2002 and 2007 showed:

- Pulse crops doubled from 5% of all crops sown to 11%, and
- The area devoted to forage legumes including butterfly pea increased from 2.9% of farm grazing area to 6.6%.

The development of a more sustainable system incorporating a pasture phase was a key objective of the CQ projects and some others in this FS evaluation. Although the expansion of butterfly pea was a major breakthrough, it was of more value in encouraging the conversion of some run down cropping soils to pasture on a semi-permanent basis. A key contributor to the general lack of success of the pasture ley was the trend in cattle prices relative to grain prices.

For the decade up to 2006 the cattle/grain price ratio actually doubled (based on ABARE 2008 prices for cattle and grain).

Table 13 shows trends for eight practices surveyed as part of ongoing evaluation activities in CQ. The 2002 baseline marks the end of the first phase and the start of the second phase. Interpretation and particularly attribution need to consider to what extent the increase to 2007 was attributable to residual momentum from the first phase, or from information from sources not funded by the project. The first issue will be less significant in CQ because the evaluation will cover the three phases combined.

Table 13: Changes in Adoption for Practices in Central Queensland ,2002-2007

Practice	% Adoption 2002	Increase to 2007 (% of CQ Region)
Zero Till	50	17
Reduced Tillage (incl. ZT)	83	12
Controlled Traffic	37	8
Changing Nitrogen seasonally	22	14
Varying seasonally (Wheat)	24	14
Varying seasonally (Sorghum)	30	27
Pulse Crops area	5	6
Area forage legumes	2.9	3.7
<u>For CQ region</u> Average number of Practices/ha	2.6	1.0
<u>Rate of increase of Practice Change/ha/annum</u>	0.2 practices	

Source: Final Report DAQ00049 based on a farmer survey.

Note some results are based on number of farmers, some on area.

The changes in adoption of the eight practices in Table 13 can be aggregated under three main categories:

- Tillage and Controlled Traffic changes;
- More flexible seasonal management; and
- Changes in rotations to include pulses and pasture leys.

The percentage levels of adoption in Table13 can be added to indicate the average number of practices adopted for the CQ Region. The percentages add to 260, or an average of 2.6 practices/ha increasing to 3.6/ha by 2007. Shepherd and Routley (2008) presented more detailed data for a selection of eight practices based on the same survey and with some overlap with the practices listed above. The average rate of increase was the same as above.

The typical pattern could be expected to be individual farmers adopting one or more practices. Each practice would have a benefit/ha and a rate of adoption. The analysis of adoption will use a rate of adoption of practices to take into account that the FS projects each developed a range of practices and that farmers would generally have adopted more than one. A simplified aggregated approach could

proceed by assuming one benefit and a rate of increase of adoption of practices. The benefit will be appropriate to the first practices adopted and would not be expected to apply to all practices. A simulation analysis of the potential total gains from adoption of many of the practices developed in the CQ project indicated an annual benefit of up to \$135/ha. (Final Report DAQ00049)

The key points that emerge from the above discussion of benefits and adoption are:

- Attribution issues need to be considered for any data on adoption from project groups and for regions;
- Evaluation will be simplified where there is more continuity in the project phases, for example in CQ;
- The droughts and rainfall patterns have had a major influence on adoption and benefits;
- The FS projects contributed to a large number of practice changes, many of which could be categorised as adding value to existing systems of reduced or zero tillage;
- The FS projects made some contribution to the already rapid adoption of reduced tillage; and
- Part of the contribution was to more flexible seasonal management including of Nitrogen applications, and of sustainable rotations with significant increases in chickpea areas and sorghum yields in particular.

The above points, together with the data available as a result of the emphasis of the projects on evaluating benefits, simplifies to some extent the next step of estimating adoption, benefits, and attribution. Table 14 is a synthesis of data from economic evaluations done in the FS projects and also in some major programs that had some overlaps or synergies with the FS projects.

Programs such as Grain and Graze (G&G) were also contributing to increased productivity in parts of the Northern Region and therefore need to be considered when attribution is estimated. The following conclusions from G&G are likely to apply to at least some of the projects in this evaluation:

"Regions generally identify the short amount of time to deliver the Program and the prolonged drought as key factors that limited achievement of outcomes meeting stakeholder needs.....The five-year time frame was too short to achieve significant adoption of recommended practices. It is likely that further benefits would have been achieved if the Program had run for a longer time period. Most quantified benefits of the Program have been derived from building on existing knowledge rather than creation of new knowledge for adoption of new practices." (Read and Petersen, 2008).

Aggregated data across all the Northern FS projects can be assembled by first estimating sub-regional adoption and benefits data based on the project-level evaluations and other data presented in Table 14.

Sub-regions and areas potentially benefiting – Some of the major projects in the early phases of Northern FS adopted agro-ecological regions crossing the Qld-NSW border. Later projects have to some extent reverted to more flexible and pragmatic boundaries recognising institutional factors. For simplicity in aggregation, an east-west approach has been used.

Table 14: Summary of Major Assumptions from Evaluations of the Northern Farming Systems and Related Projects

Project and Scope	Date of Analysis	Benefit Basis	Benefit/ha	Adoption	Attribution	Without Project Scenario
DAQ382 (CQ)	1996	Project Proposal. Major components of annual and perennial ley legumes assumed.	\$57/ha	Additional 2.5% of sub-region for 20 years	na	20% decline in fertility
DAQ382 (CQ)	2005	Dawson sub-region case study farm converting to Zero Till; (a ley alternative was not profitable)	\$22/ha		na	na
Chudleigh (2005) for DAQ49 (CQ)	2005	10 years of project costs and benefits. Risk analysis included.	\$20 to \$35/ha	75-80% for Reduced Tillage etc	75%	Lagged 5 years
LWA Controlled Traffic (LWA 2005)	2005	Major CQ project during 1990s developing and promoting CT.	10% yield increase, more opportunity cropping, increased costs, and reduced erosion.	From zero to 12% of region in 2003 and then constant.	100%	Adoption of Reduced tillage
CSC41 (SEQ, NE NSW)	1997	Project Proposal. Ex ante analysis based on changed rotation, additional Nitrogen etc.	\$28/ha	Additional 10% of 1.8m ha over 8 years from 1998	na	Adoption is additional
DAQ50 (SEQ NE NSW Phase 2)	2006	Based on 4 case studies of 18 issues covered in project with Zero Till, additional crops and Nitrogen.	\$28.33/ha average on 0.575m ha.	Reaching about 0.5m ha over 3 years		About one half rate and level of adoption with project
DAQ499 (SW)	2000	Project Proposal. Increased	\$40/ha across region	40-70% in 3-5 years	na	Adoption is

Qld)		yields and new crops (chickpeas).		over 460,000 ha cultivation.		additional
DAQ499 (SW Qld)	2005	Project Final report. Includes Phase 1 report. Based on 5 case study farms and reduced tillage, changed cropping.	\$30/ha	Double % of area using Nitrogen and % of area using Zero Till over 15 years.	50% attributed to Phase 1 and 2 projects.	Lagged 5 years
CWF1 (Central West NSW)	1998	Project Proposal. Productivity increase.	\$8/ha	Additional 60% in 6 years over 1.4m ha	na	Adoption is additional
Northern NSW (Scott and Farquharson 2004)	2004	Investment from late 1970s to 2002 in Research and Extension of Conservation Farming by NSW Agriculture	Benefits for 7 sub-regions of Reduced or Zero Till. Reduced till average of about \$50/ha	Increased area of No Till of 1.4% pa to 2020.	About one third to each of NSW DPI, GRDC, and Other.	Conventional tillage, wheat only system.
NSW DPI (2008)	2008	Based on a range of budgets on conversion to reduced tillage in CW NSW	\$21/ha	na	na	na
Grain & Graze (Read and Petersen, 2008)	2008	Mixed enterprise producers in 9 regions	6% perceived increase in profit for 3 sub-regions in Northern GRDC Region	1,100 farmers from the target of 6,800, and with benefits maintained for 10 years.	23% of adoption target (for all 9 regions)	

Note: na Not applicable or not attempted

The project DAQ471 on the intensive cropping of mainly small areas of high value peanuts was included in the SEQ NE NSW sub-region. The estimates of areas benefiting as shown in Table 15 take into account the major fluctuations in areas cropped because of the high proportion of droughts during and in some cases since the projects. The areas have also been discounted to some extent to take account of sub-region variation in areas of reduced tillage (as shown in Table 11) which are likely to be the main areas benefiting from the projects. No allowance has been made for expansion of cropping in coming decades, for changes in prices from the typical values ruling during the FS projects and prior to recent increases, or for any current or potential impacts of climate change.

Table 15: Summary of Assumptions Made on Adoption Patterns and Benefits for the Four Sub-regions in the Northern Region

Sub-Region	Average Area of crop (000 ha)	Project Durations		Adoption			Annual Benefit/ha (for a practice change)
		Start	End	Start year	Max. year	Practice Change /decade /ha	
CQ	700	1996	2008	1999	2011	1.5	25
SEQ-NE NSW	1,400	1997	2008	2000	2011	1.0	20
SWQ-NW NSW	1,000	1999	2008	2002	2011	0.75	20
CW NSW	600	1998	2008	2001	2011	0.5	15

Adoption patterns in the four sub-regions – The years when adoption starts and reaches a maximum are simply the years when the first and last projects in the sub-region start and end years, but with a three year lag. In some cases, for example for SWQ and NW NSW, there were major projects that concluded before the projects in this grouping of FS projects began. The SWQ Phase 1 project, which ended in 2000, was very successful in increasing adoption of a number of practices. There was also a similar project in Northern NSW not included in this grouping. Those projects were likely to have had flow on effects that need to be taken into account in estimating additional benefits from the FS projects in this evaluation.

The assumed lag in adoption recognises that research and extension activities take time to have a regional impact and also that benefits for some practices may take time to reach a more stable level. The three year period may appear short but it only defines the year when increased adoption begins. Many of the projects were able to demonstrate regionally significant levels of practice change beginning within a few years. Adoption was assumed to reach a maximum in three years from the end of the last project in the sub-region to reflect that there would be some momentum from the project activity but that the level of resources to maintain that would be diminished. From a CQ survey, Shepherd and Routley (2008) included respondent's estimates of likely adoption in five years time. On average the rate was expected to reduce to one quarter of that actually applying during the previous five years.

Adoption rates for practice change – Different rates have been assumed to reflect mainly the continuity of effort and drought impacts in each region. In CQ there

have been 2 major phases and a third is in progress. The current project has a focus on fine tuning which would also support an assumption of decreasing returns. All phases in CQ have enjoyed the same boundaries and the same lead agency. The increase in adoption of practices of 1.5/decade is based on the CQ survey data of about 2/decade for adoption of eight specific practices as measured by number of farmers or regional area measures. The low rate of a 0.5/decade for CW NSW reflects in particular the extreme drought experience and also the impact that had on clearly defining some key practice changes across 10 regional sites. The intermediate rates for the other two sub-regions across Northern NSW and Southern Queensland are estimates that reflect less continuity and regional consistency compared with CQ.

Annual Benefit/ha – the increases reflect in part the adoption pattern and also the drought pattern. To put the data in context, the benefit is in the range of a 5-10% yield increase, which is consistent with a large amount of research experience on the benefits of reduced tillage. As argued previously the benefits are an aggregate and an average of a range of enhancements and fine tuning for farmers adopting a range of practices.

There are three further assumptions to be made in order to fully define the benefits from the FS investment. They can be made at a Northern region level and are developed in the following.

Decline in benefits/ha – The key issue is whether the knowledge or products developed are subject to deterioration so that they do not provide a base for further research to build on. Chudleigh (2005) assumed for a CQ evaluation that the benefits would decline rapidly after a few years because of unforeseen changes in the farming environment. This could be particularly true for FS research that is effectively agronomic research, for example seeking ongoing local adaptations to new diseases or weeds. But offsetting that view is that for some benefits farmers will have increasing farmer capacity to develop solutions to emerging issues. On balance the conservative assumption is made that benefits will decline slowly from the maximum reached by 2.5% of the maximum value annually for the remainder of the analysis.

Attribution –As part of the evaluations done for the CQ projects, the project team assessed how they felt the project had contributed to practice change. The average contribution across a range of practices was about 30%. Aspects of Butterfly pea management ranked highest. Other significant contributors included consultants, other farmers, publications, and other QDPI projects. However in terms of attribution, the contributors need to be based more on the resources involved and the original source of the information. For example much of the information could have come from earlier phases of the project or from other regions. The evaluation of conservation farming in Northern NSW by Scott and Farquharson (2004) developed some attribution estimates which suggested for these generally similar FS projects involving funding from GRDC and partner agencies, an attribution of approximately 2/3 or 66% was appropriate. Attribution to activities of other agencies and advisers not directly involved accounted for the balance. Given the likely underestimate of an influence measure as a measure of attribution in the CQ example, an estimate of 66% will be used.

The Counterfactual – In the absence of the GRDC investment, it is assumed that it would have taken five years before benefits from other projects began to be adopted. Note that benefits from the FS project are assumed not to begin for three years. The main feature that needs to be considered in determining a plausible scenario is the magnitude of the early investments made in the FS

projects. For example the first FS project in CQ began in 1996 with a GRDC budget of over \$3m and with much larger in-kind inputs integrating resources of State Departments. The most feasible assumption is that if that GRDC had not funded that project, they would not have then funded similar or alternative FS projects even a few years later. Any projects developed by other agencies would have been minor and less integrated in comparison. External funding is normally needed to foster and sustain agency cooperation on a significant scale. Overall therefore the assumption made is that benefits for all the sub-regions would only have been one third of those achieved by the FS projects and there would be a lag of five years from when the FS projects began in each sub-region.

Table 16 summarises the major assumptions made in undertaking the evaluation.

Table 16: Summary of Major Assumptions

Description	Value	Source (by the author unless stated)
<u>With GRDC investment</u>		
Average area of crop benefiting	3.7 m ha	Table 15 for 4 sub-regions
Crop production factor to 2008	Ratio of production to average 1994-2008.	Data sources as in Fig 1. for Northern Region
Benefit/ha	\$10-\$30/ha	Table 15 (range for 4 sub-regions)
Adoption lag	3 years	Table 15 for all sub-regions
Adoption rate for practices until maximum reached	0.5 to 1.5 practices/decade	Table 15 (range for 4 sub-regions)
Adoption maximum from end of last project	3 years	Table 15 for all sub-regions
Benefit decline (after reaching maximum)	Per annum decline of 2.5%	Allows for slow deterioration of research value/ha .
Attribution of Benefits to GRDC FS projects	66%	Scott and Farquharson (2004)
<u>Without GRDC investment</u>		
Lag until benefit starts from date of first project in sub-region starting	5 years	Major investments were in the early years so alternative R&D would have taken longer to make an impact
Benefits	1/3 of level with the GRDC investment	Based on the magnitude and effectiveness of the GRDC investment compared with likely alternatives.
<u>General Assumptions</u>		
Indexation	CPI	To 2008/09 dollar values using CPI
Discount Rate (%)	5	As prescribed by GRDC
Period of analysis (years)	25	From last year of GRDC investment

8. Cost Benefit Results

All past costs and benefits were expressed in 2008/09 dollar terms using the CPI. All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 25 years from the last year of investment (2008/09) to the final year of benefits assumed (2033/34).

Investment criteria were estimated for both total investment and for the GRDC investment alone. Each set of investment criteria was estimated for different periods of benefits. The investment criteria were all positive as reported in Tables 17 and 18.

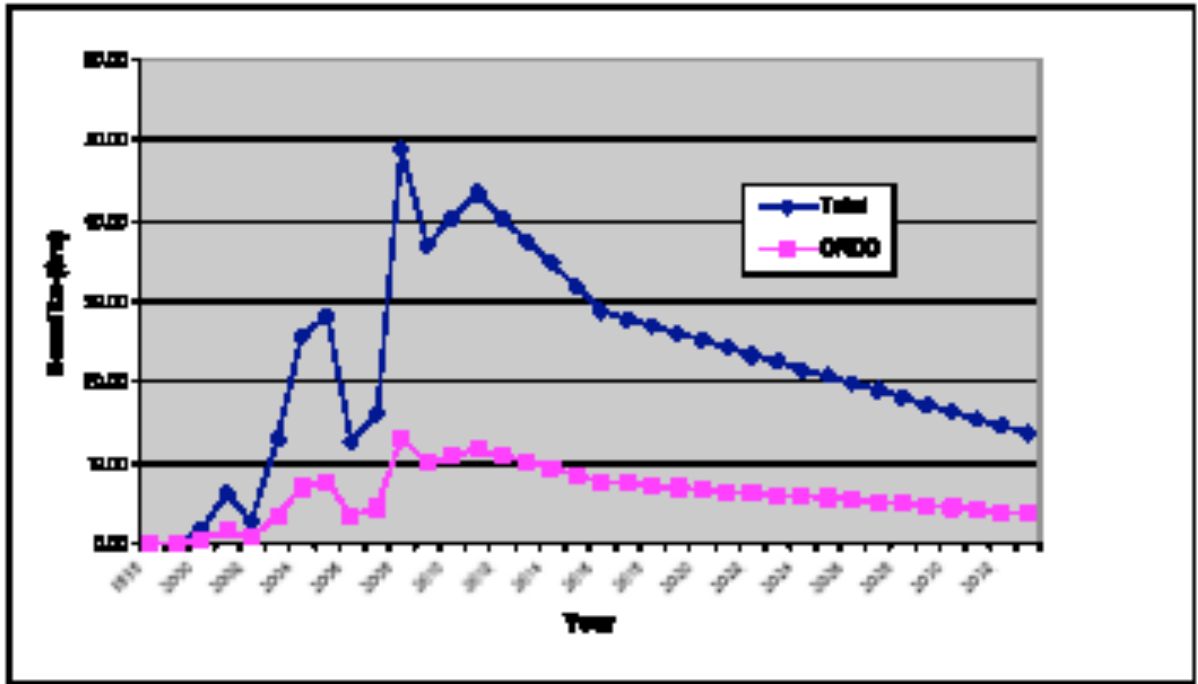
Base Case

Based on the assumptions in section 7, the estimated increased cash flows attributable to the investment were estimated and projected over 25 years as shown in Figure 3. The cash flows evaluated are the increased profits to farmers from the additional benefits, particularly the yield increases achieved. The early pattern incorporates lower benefits as a result of the decreased production due to the major drought years. The general pattern of a rapid rise to a peak and then a decline reflects the assumption of adoption reaching a peak three years after the end of the projects in each sub-region. The subsequent decline reflects deterioration in the value of the research as new issues emerge requiring further research effort.

The net present values of the total investment and the GRDC investment are shown in Tables 17 and 18 respectively. This is considered to be the benefit accruing to Australia. The majority of the benefit accrues to grain growers as the majority of grain is exported at export prices or sold into a domestic feedgrain market dominated by feed wheat in most years. Therefore increased production is unlikely to have a major impact on prices. In terms of the Rural Research Priorities the major contribution is to the Productivity and Added Value priority. As shown in Section 4 there were some other contributors to the other priorities, but these benefits have not been quantified.

The analysis demonstrates that under the assumptions the investment is likely to continue to achieve satisfactory returns and that the benefits accrue rapidly from the early years.

Figure 3: Annual Benefit Cash Flow



**Table 17: Economic Impact of the Total Investment
(2008/09 \$ terms, 5% discount rate)**

Total Investment	0 Years	5 Years	10 Years	25 Years
Cumulative PV of Benefits	184	364	472	540
Cumulative PV of Costs	117	117	117	117
Cumulative NPV	67	248	355	423
Benefit Cost Ratio (BCR)	1.58	3.12	4.04	5.23
Internal Rate of Return (%)	18.9	27.7	28.9	29.1

**Table 18: Economic Impact of the GRDC Investment
(2008/09 \$ terms, 5% discount rate)**

GRDC Investment	0 Years	5 Years	10 Years	25 Years
Cumulative PV of Benefits	50	98	127	145
Cumulative PV of Costs	31	31	31	31
Cumulative NPV	18	67	96	114
Benefit Cost Ratio (BCR)	1.58	3.12	4.04	5.23
Internal Rate of Return (%)	18.9	27.7	28.9	29.1

The following sensitivity analyses to illustrate other scenarios concentrates on pessimistic and optimistic factors influencing the overall level of benefits as shown above.

9. Other Scenarios

As concluded in the previous section, the adoption rates in the early part of the analysis and perhaps to a lesser extent the benefits/ha can be considered achieved with more confidence than those later in the period analysed. Optimistic and pessimistic scenarios therefore need to be developed by adjustments particularly to the assumptions determining the medium term level of benefits.

9.1 Optimistic

The additional benefits in the base case are essentially determined by the rate of adoption and the benefit/ha less the benefits that would accrue if GRDC had not funded the FS projects. The estimates of adoption and benefits/ha are based on experience during the projects. The benefits in particular were based on budgets of what should be achievable. Anecdotal evidence often from leading farmers could be marshalled to show they are conservative. On the other hand for an analysis applicable to a large diverse region, a conservative approach is favoured. The assumption made on likely benefits if GRDC did not invest is hypothetical and subject to a high level of uncertainty. Therefore the optimistic scenario will be defined by halving the benefits assumed in the 'without' situation as summarised in Table 19. The change in benefits is relatively minor suggesting that the analysis is not very sensitive to assumptions on the benefits if GRDC had not invested in the FS projects.

**Table 19: Return to the GRDC Investment – Optimistic Scenario
(2008/09 \$ terms, 5% discount rate)**

Optimistic	0 Years	5 Years	10 Years	25 Years
Cumulative PV of Benefits	189	391	528	617
Cumulative PV of Costs	117	117	117	117
Cumulative NPV	73	274	411	501
Benefit Cost Ratio (BCR)	1.62	3.35	4.52	6.09
Internal Rate of Return (%)	19.6	28.6	29.9	30.2

9.2 Pessimistic

The pessimistic scenario reduces the early benefits, assumes the peak is reached earlier in 2008, and also assumes a more rapid decline in benefits. The specific assumptions are:

- A reduction of one third in benefits up to a new peak year in 2008 compared with 2011 in the base case,
- Benefits declining from 2008 to zero by 2018.

Results are shown in Table 20. There are several risk factors that could contribute to the longer-term decline in benefits. A pessimistic view on the any potential impacts of climate change including higher costs for key inputs such as fuel and fertiliser is feasible.

Potential impacts and adaptations have been reviewed by Howden et al (2008). Gunasekera et al (2007) in a preliminary study of economic impacts on Australian agriculture have indicated production impacts of a 9.2 per cent decline (from the

reference case of no climate change impacts) in Australian grain production by 2030. The last decade has included several major droughts, higher than historic drought incidence, but possibly realistic for the next 25 years given projections of up to 20 per cent more drought months over most of Australia by 2030 (CSIRO and the Bureau of Meteorology 2007).

However, the Northern Region is likely to be less impacted by climate change than other cropping regions and there is scope for adaptation to reduce the impacts. But given uncertainties on factors affecting supply and demand over the next two decades, the evaluation therefore used conservative estimates in relation to future benefits. No trend was assumed in grain production from the region. Industry expansion would clearly make the pessimistic scenario less likely.

Table 20: Return to GRDC investment – Pessimistic Scenario
(2008/09 \$ terms, 5% discount rate)

Pessimistic	0 Years	5 Years	10 Years	25 Years
Cumulative PV of Benefits	92	182	207	207
Cumulative PV of Costs	117	117	117	117
Cumulative NPV	-25	65	90	90
Benefit Cost Ratio (BCR)	0.79	1.55	1.77	1.77
Internal Rate of Return (%)	Neg	14.9	17.5	17.5

The results in Table 20 of the more pessimistic assumptions on the level of benefits reached and on their long-term decline do not have a major impact on the level of returns likely to be achieved. Overall, there is greater confidence in the economic benefits to date and the adoption levels. The results for the pessimistic scenario support a conclusion that the investment is still profitable notwithstanding lower levels of confidence on medium term benefits.

The implication as for the optimistic scenario is that the results of the analysis are robust. The rapid early increase in adoption that has already been achieved is the key factor. The final section will consider lessons learned and what might be done to reduce the likelihood of the pessimistic scenario becoming more relevant, particularly for future FS projects.

10. Conclusions and Lessons Learned

The evaluation using the best available estimates of benefits suggested the investments by GRDC in more profitable and sustainable systems in the Northern Region have been successful. The benefit-cost ratio based on outputs since 1996 is of the order of five to one. The actual investment by GRDC was almost \$20 million. Partners in the projects, primarily State Departments of agriculture and natural resource management contributed \$52 million. The Net Present Value of the overall investment over 25 years is estimated at \$423 million. The projects began in 1996 and it is estimated that break even on the investment has already been achieved, even after taking into account the impacts of the recent droughts on production and on benefits.

The FS projects in many respects pioneered an action learning approach based on active participation of farmer groups in research planning. The projects clearly generated a high level of initial enthusiasm from participants. That often translated into relatively rapid outcomes as shown from active monitoring and evaluation built into projects. One project reviewed the group learning process and showed that success depended on the nature of the topic and on skilled facilitators able to exploit the diversity within the group.

Some of the impressions and learnings from this evaluation include:

- Project boundaries based initially on agroecological boundaries across State borders gave way to more effective pragmatic approaches;
- The important role of skilled facilitators in ensuring participation in diverse groups;
- The need to carefully consolidate priorities from the extensive list of issues generated by the group processes involving graingrowers and researchers;
- The need for a balanced approach to ensure progress regionally approaches that achieved by the probably more innovative farmers in groups;
- The extent to which products, monitoring of adoption and linkages are maintained post project, for example the longevity of products developed during the projects, and of the research and agency linkages fostered by the project particularly in the areas more remote from the major research centres; and
- Whether a participatory approach based on action learning groups has evolved or needs to evolve where there is a trend to develop or make greater use of other industry networks including consultants and agribusiness.

The above could be subject to more intensive review to determine their more general relevance to FS research.

The emphasis on evaluation in the projects generated a wealth of data on adoption of a wide range of practices. The data was more useful for this evaluation in sub-regions such as Central Queensland where FS projects have continued since 1996. Most projects included economic evaluations of impacts based on Best Practice budgets rather than actual farmer performance more useful for a regional evaluation.

For this evaluation conservative estimates of adoption of practices and benefits/ha were made in each of four sub-regions and then aggregated for the Northern Region. There were differences between sub-regions, which were at least partly accounted for by their drought experience, project continuity and project scale. There was limited achievement of aspirational objectives to

incorporate pasture leys, most likely related in particular to an unfavourable beef/grain price trend for much of the period resulting simply in increased areas of pasture.

The Cost-Benefit Analysis also needed estimates of attribution and likely benefits if GRDC had not invested in the FS projects. Most practices researched and promoted in the FS project had already been the subject of considerable research. Some of the research in the projects was concerned with further local adaptations, for example in a rotation context, to increase confidence in their value. The assumption was made that benefits in the absence of the GRDC investment would only be one-third of those achieved with the investment, and further there would be a longer lag. Many of the FS projects had large budgets and a clearer integrated focus compared with traditional research up to that time.

The evaluation provided strong support to the view that a comprehensive regionally applied farming systems approach has made a substantial contribution to the more rapid development and adoption of many practices at a regional scale. The benefits that have been estimated are increased profitability, for example from more effective rotations. Increased adoption of reduced tillage would have also contributed to reductions in off-site impacts on the environment additional to those already made from the prior expansion of reduced tillage. These have not been evaluated.

The uncertainties in the estimation included attribution and how rapid progress might have been if GRDC had not invested. It is likely some of benefits achieved by the FS projects would have been achieved in any case, as many were simply further adapting and fine tuning existing practices. Allowance was made for some deterioration in the benefits over time on the basis that FS research would need some further maintenance research. The benefits are conservative, particularly because they do not value environmental benefits or longer term benefits likely to be generated from improved capacities for local management of research.

Finally, it should be noted that the evaluation has been against a baseline of the likely developments if GRDC had not invested in FS-related research in the Northern Region. Therefore this evaluation has not examined the question of how the FS approach compares with alternative approaches to achieving the same objectives. The FS approach in the Northern Region varied between projects and evolved to reflect learnings from previous projects, and to respond to changes in communication technologies. It is likely too that the greater role that farmer advisers and consultants now have will change the way FS projects are carried out in future.

Acknowledgments

Grains Research and Development Corporation, Canberra
Vince Fernandes, Business Analyst
Stuart Kearns, Manager Validation and Integration

Consultants contacted
David Freebairn, CONICS, Brisbane
Greg Rummery, Greg Rummery Consulting, Walgett
Richard Price, Kiri-ganai Research, Canberra
Graham Spackman, Graham Spackman & Associates, Emerald

Northern Region Farming Systems Projects and other GRDC projects

Principal Investigators or Project Personnel for most of the 18 projects included in the evaluation were contacted and contributed valuable information. In particular the following responded to a number of follow-up requests for more detailed information:

Mike Bell,	Queensland Department of Primary Industries, Kingaroy
Richard Daniel,	Northern Grower Alliance, Toowoomba
Jodie Dean,	Central West Farming Systems, Condobolin
Phil Kokic,	ABARE, Canberra
David Lawrence,	Queensland Department of Primary Industries, Toowoomba
Richard Routley,	Queensland Department of Primary Industries, Toowoomba
Fiona Scott,	NSW Department of Primary Industries, Tamworth
Anne Shepherd,	Queensland Department of Primary Industries, Emerald

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