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An impact assessment of conservation tillage research in China and Australia

99

ACIAR IMPACT ASSESSMENT SERIES

An impact assessment of conservation tillage research in China and Australia

Joseph Abell, Peter Chudleigh and Talia Hardaker
Agtrans Research, Brisbane

ACIAR Impact Assessment Series Report No. 99

Revision and update of ACIAR Impact Assessment Series Report No. 33
Research into conservation tillage for dryland cropping in Australia and China (Vere 2005)

ACIAR

2021

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Foreword

The international partnerships that underpin research supported by the Australian Centre for International Agricultural Research (ACIAR) aim to improve the productivity and sustainability of agricultural, forestry and fisheries systems, as well as the resilience of food systems in partner countries. Importantly this research also helps improve Australian agricultural systems.

Between 1992 and 2003, the Australian Centre for International Agricultural Research (ACIAR) invested in two projects addressing aspects of conservation tillage in China and controlled traffic farming in Australia:

- 'Conservation/zone tillage research for dryland farming' (LWR2/1992/009, also known as ACIAR project 9209)
- 'Sustainable mechanised dryland grain production' (LWR2/1996/143, also known as ACIAR project 96143).

An initial impact assessment of this work—*Research into conservation tillage for dryland cropping in Australia and China*, ACIAR Impact Assessment Series Report No. 33 (Vere 2005)—found an overall benefit:cost ratio of 36:1.

The full impact of many innovations in agriculture, especially complex farming system changes like the introduction of conservation agriculture, are realised over decades and cannot be properly evaluated when the research first takes place. Understanding the typical life cycle of innovation in agriculture, and encouraged by our partners in China, in 2019 ACIAR commissioned a new independent assessment of the return on investment from this long-term work.

The new analysis confirmed the key findings of the first assessment—that the key impact of the ACIAR projects was to bring forward the delivery of controlled traffic farming outcomes in Australia and accelerate the adoption of conservation tillage practices in China. Further, the investment criteria estimated were positive and much higher than the results reported in 2005.

Based on the most conservative estimates, the new assessment found a benefit:cost ratio of 181:1, with a realistic scenario showing that the returns were likely to have been much higher. In addition, consultation with key stakeholders in China revealed a very positive attitude by Chinese authorities and research leaders towards:

- the initial investment in conservation tillage research in China by ACIAR
- the impact it has had on China's cropping sector (conservatively impacting 12–16 million hectares)
- the capacity built for conservation tillage research and development, and machinery manufacture in China.

While not seeking to detract from the positive findings, the study also highlighted to ACIAR the challenges of trying to assess returns on investment after such a long time. The assumptions built into the assessment models, and the requirement to quantify attribution based on these, can risk ACIAR presenting benefit:cost ratio estimates that are hard to believe and that fail to reflect the many other factors contributing to rapid change and development in a sector. Recognising this risk, the assumptions used in this study were extremely conservative.

The message from this study is clear: timely agricultural research partnerships can speed up adoption of transformational practices and deliver extraordinarily high value to both Australia and our partner countries. In partner countries like China, where the land areas and numbers of farmers involved can be very large, high adoption rates of improved practices inevitably translate to very large returns on investment. Along with similarly high value returns from collaborations on livestock, citrus production and forestry, this study shows the value to both countries of ACIAR collaboration with our Chinese research partners.

Andrew Campbell
Chief Executive Officer, ACIAR

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Abbreviations

A$	Australian dollar
ABARES	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACIAR	Australian Centre for International Agricultural Research
CAU	China Agricultural University
CSAM	Centre for Sustainable Agricultural Mechanization
CT	conservation tillage
CTF	controlled traffic farming
GDP	gross domestic product
ha	hectare
IAS	Impact Assessment Series
MoA	Ministry of Agriculture (China)
n/a	not applicable
NSW	New South Wales
PVB	present value of benefit
Qld	Queensland
RMB	Renminbi (official currency name of China) (1 yuan = 1 renminbi)
SA	South Australia
t	tonne
Tas	Tasmania
Vic	Victoria
WA	Western Australia

Glossary of economic terms

Cost–benefit analysis	An economic analysis technique for assessing the economic merit of a proposed initiative by assessing the benefits, costs and net benefits to society of the initiative. Aims to value benefits and costs in monetary terms wherever possible, and provide a summary indication of the net benefit.
Benefit:cost ratio	Ratio of the present value of economic benefits to the present value of economic costs of a proposed initiative. Indicator of the economic merit of a proposed initiative at the completion of cost–benefit analysis. Commonly used to aid comparison of initiatives competing for limited funds.
Discounting	Converting money values that occur in different years to a common year. This is done to convert the dollars in each year to present value terms.
Implicit price deflator for GDP	The implicit price deflator for GDP is a price index for all final goods and services produced, and is calculated as the ratio of nominal GDP to real GDP. The GDP deflator expresses the extent of price level changes, or inflation, within an economy. The implicit price deflator for GDP is used to convert past, nominal dollar terms to current, real dollar terms in a cash flow analysis.
Internal rate of return	The discount rate that makes the net present value equal to zero. Internal rate of return must be greater than or equal to the discount rate for an initiative to be economically justified. The discount rate is also known as the hurdle rate.
Investment criteria	A set of parameters used by decision-makers to assess or compare initiatives. Investment criteria may include the benefit:cost ratio, net present value and internal rate of return.
Net present value	The combined discounted present value of one or more streams of benefits and costs over the appraisal period. The term 'net' denotes that the net present value is calculated as present value of benefits minus the present value of costs.
Present value of benefits	The sum of the discounted benefit streams (cash flows) over the appraisal period.
Present value of costs	The sum of the discounted cost streams (cash flows) over the appraisal period.

Projects evaluated

ACIAR projects	Conservation/zone tillage research for dryland farming (LWR2/1992/009) Sustainable mechanised dryland grain production (LWR2/1996/143)
Collaborating organisations	University of Queensland Farm Mechanisation Centre, Gatton China Agricultural University, Beijing
Project leaders	Dr Jeff Tullberg (University of Queensland) Professor Gao Huanwen (China Agricultural University)
Principal researchers	Dr Jeff Tullberg Professor Gao Huanwen
Project duration	LWR2/1992/009: January 1993 to December 1996 LWR2/1996/143: July 1997 to June 2003
Total ACIAR funding	$1.429 million (nominal dollars)
Project objective	To develop and evaluate improved reduced or conservation tillage technologies for sustainable dryland grain production in Australia and China
Location of project activities	Gatton, Queensland, Australia Shanxi Province, China

Source: ACIAR IAS 33 (Vere 2005).

Summary

Between 1992 and 2003, the Australian Centre for International Agricultural Research (ACIAR) invested in two consecutive projects on aspects of conservation tillage (CT) in China and Australia. David Vere completed an impact assessment of the investment in the two projects in 2005 reported in *Research into conservation tillage for dryland cropping in Australia and China*, ACIAR Impact Assessment Series Report No. 33 (IAS 33). The evaluation demonstrated positive economic, environmental and social benefits to both China and Australia.

However, given that the initial evaluation was conducted soon after the completion of the second project investment, ACIAR considered that many of the largely prospective assumptions made in the 2005 assessment could be validated and/or revised, and supported with subsequent observations and available data from China and Australia, particularly in relation to adoption of CT and other associated impacts. So, in 2019, Agtrans Research was contracted by ACIAR to undertake an updated impact assessment.

The 2019 updated assessment was conducted in line with *Guidelines for assessing the impacts of ACIAR's research activities*, ACIAR Impact Assessment Series Report No. 58 (IAS 58) and used a producer surplus approach to estimate the value of the key impacts of the ACIAR investment. The current analysis confirmed Vere's finding that the key impacts of the ACIAR projects was bringing forward the delivery of controlled traffic farming (CTF) outcomes in Australia and accelerating the adoption of CT practices in China.

New, up-to-date information and data associated with the adoption of CT in China and CTF in Australia (along with improved estimates for other key assumptions) contributed to a more reliable and validated estimate of the positive impacts of the ACIAR project investments made from 1992 to 2003.

There also have been environmental and natural resource management impacts in both Australia and China. These include reduced soil erosion, reduced wind erosion, increased soil moisture holding capacity, increased carbon sequestration via higher crop yields, less straw burning and air pollution, and lower greenhouse gas emissions.

On the other hand, there might have been some negative environmental impacts through increased pesticide use. There have also been social impacts in China from the ACIAR projects. While there was not a large gender effect, feedback from stakeholders in China indicated that there had been a labour-saving impact, with a reduced need for labour from older people in rural areas, where agricultural labour shortages have been common.

In addition, due to CT and CT machinery companies being based in rural areas, adoption of CT in China has created career opportunities for local workers to stay in their hometowns and local regions. The project also yielded significant capacity building impacts through greater training and research capacity in CT.

A secondary impact is that the increased Chinese training and research capacity has led to direct impacts in other Asian and African countries due to further Chinese extension and teaching of CT in these countries, often through joint research, development and extension activities.

Retrospective impact evaluation assessments over long-time horizons are no less complex and challenging for evaluators than forward looking assessments. The 2019 update of IAS 33 is a good example of the range of challenges faced, as the evaluation took place in a period that saw significant change and economic development in China.

Determining the impact that can be attributed to ACIAR investment in CT within a complex and rapidly changing Chinese agriculture sector, and economy more generally, is a formidable task.

This is further complicated by broadscale changes in relative prices of agricultural inputs and outputs over time. Applying 2019–20 prices to the impacts of an investment made in 1993, although necessary for the current analysis, might not take into account complicating factors.

Retrospective impact evaluation assessments are no less bound by the need to use assumptions in the modelling of benefits and costs over time than their prospective counterparts.

Key drivers of the higher investment criteria in the updated assessment included the following:

- Adoption of CT/CTF in China and Australia was much higher than previously predicted. In China, CT adoption was four times higher than assumed in the 2005 assessment, whereas in Australia adoption of CTF was three to five times higher.
- Cost saving per hectare for adoption of CT in China might be higher. The base assumption of total production cost savings of about $189/ha included labour, fuel, water and fertiliser savings. The available data did not allow the various components of the total savings to be broken down. So, including labour savings creates some difficulty in the analysis, as the significance of any labour savings between 1992–93 and present day might have changed. For example, current rural labour shortages in China are likely to have increased the importance of labour-saving agricultural practices in recent years.
- Wheat and maize crop areas and production in China was higher. Vere (2005) estimated total, average annual crop production of 133,122,000 tonnes of wheat and maize (combined) in China. Actual total wheat and maize production in China from 2005 was higher than predicted by Vere, due to various changes to policy and other developments in China. Total production of wheat and maize in China was reported at 143,968,780 tonnes in 2018.
- A higher lag than anticipated—though the benefits in Australia were driven by a 3-year lag similar to what was assumed in the 2005 assessment, the benefits in China (99% of the present value of benefits) were driven by a 10-year lag (versus a 3-year lag in the original assessment).
- Current prices for wheat in Australia, and wheat and maize in China are higher than those estimated in 2005. Further, in the past, the China Central Government implemented policies that affected crop prices. It is unclear what impact such policies might have had on the 2005 impact assessment. But more recently, China has undertaken a campaign to bring domestic prices more in line with international market prices by reducing policy support, which served as a floor for prices of standard wheat.

Overall, the findings of the updated 2019 assessment of IAS 33 indicate highly favourable outcomes for the original ACIAR project investment.

In addition, consultation with key stakeholders in China revealed a very positive attitude by Chinese authorities and individuals towards the initial investment in CT by ACIAR, the impact it has had on China's cropping sector, and the capacity built for CT research and development and machinery manufacture in China.

These findings should provide confidence to ACIAR and its funding partners that the original investment in the two ACIAR projects has produced a significant and positive return on investment.

1 Introduction

This impact assessment provides an update of an earlier impact assessment undertaken for ACIAR—*Research into conservation tillage for dryland cropping in Australia and China*, ACIAR Impact Assessment Series Report No. 33 (IAS 33) by David Vere in 2005.

The assessment evaluated the impact of two ACIAR-supported research projects associated with conservation tillage (CT) in the People's Republic of China (hereafter referred to as China) and controlled traffic farming (CTF) in Australia.

Before the investment by ACIAR in the early 1990s, little attention had been paid to CT in China, apart from that by the research group at China Agriculture University (CAU). Previous research in CT from Canada did not translate adequately to Chinese conditions, due to the size of plots and available machinery. Despite this, as soil erosion had become a major issue and there was a need for increased crop yields and mechanisation, CT did present an opportunity for farmers, despite some opposition to CT by traditional farmers, researchers and government.

In Australia, precision traffic and minimum or zero till were not new concepts when the first ACIAR project began in 1992–93, but major impediments existed to adoption of what is now known as CTF. In particular machine standardisation was a key issue and the demonstration of practices and associated benefits presented an opportunity to facilitate interest and adoption in CTF.

ACIAR invested in two research, development and extension projects in China (CT focus) and Australia (CTF focus) between 1992 and 2003:

- 'Conservation/zone tillage research for dryland farming' (LWR2/1992/009, also known as ACIAR project 9209)
- 'Sustainable mechanised dryland grain production' (LWR2/1996/143, also known as ACIAR project 96143).

In 2005, not long after the completion of the two projects, David Vere conducted an impact assessment of the investments (Vere 2005). The assessment demonstrated positive economic, environmental and social benefits to both China and Australia

As of 2019, the original impact assessment was 14 years old, and ACIAR considered that many of the largely prospective assumptions made in the 2005 assessment could be validated and/or revised, and supported with subsequent observations and available data from China and Australia, particularly in relation to adoption of CT and other associated impacts. The updated 2019 impact assessment of ACIAR investments in CT in China and CTF in Australia relies on:

- information collected in regional wheat and maize producing regions of north China
- statistical information available from other sources in both China and Australia
- consultation with industry and other published materials.

2 Research into conservation tillage for dryland cropping in Australia and China (IAS 33)

2.1 Introduction

The original impact assessment of the two ACIAR projects was conducted in 2005 (Vere 2005). The two projects included in the assessment were:

- 'Conservation/zone tillage research for dryland farming' (LWR2/1992/009, also known as ACIAR project 9209)
- 'Sustainable mechanised dryland grain production' (LWR2/1996/143, also known as ACIAR project 96143).

The impact assessment was published by ACIAR in March 2005.

The two projects evaluated covered investments in conservation tillage (CT) in China and controlled traffic farming (CTF) in Australia made by ACIAR and other partners[1] between 1992 and 2003. Research was carried out in both Australia and China. The two projects were evaluated together as project LWR2/1996/143 was a direct follow-on from LWR2/1992/009.

The investment made by ACIAR and its partners addressed whether CT and CTF technology developed in Australia could successfully be adapted in the north-western provinces of China[2].

In addition, standardisation of CTF machinery was required in Australia, as well as demonstration of the benefits from CTF to encourage adoption in Australia. The purpose of the original assessment was to identify and value the actual and potential impacts of the investment in the two ACIAR projects, covering the combined benefits to China and Australia.

2.2 Methods and assumptions

While the impact assessment conducted by Vere (2005) was undertaken after both projects had finished, the assumptions for the assessment were largely prospective. The outcomes for projects LWR2/1992/009 and LWR2/1996/143 necessarily included predictions based on observations made just after the ACIAR projects had been completed. So, the projected outcomes and impacts could not be verified at that time.

2.2.1 Methods

The impact assessment by Vere (2005) used a partial-equilibrium model to measure changes in economic surplus. The benefits and losses from the changes were estimated for both producers and consumers, as well as for any producers in non-adopting regions.

The impact assessment model included changes in the price of wheat and maize because of the ACIAR investment (for wheat in Australia and wheat and maize in China). Benefits were measured by economic surplus, generated by a downwards supply shift, driven by a cost reduction. The methods used in the Vere (2005) impact assessment were largely consistent with subsequent impact assessment guidelines (IAS 58), apart from some minor reporting divergence.

The 2005 impact assessment was undertaken in an ex-ante benefit–cost context where the projects' costs were known, and the benefits were projected estimates of the expected project returns (Vere 2005).

Due to analysis being based only on prospective benefit assumptions, the value of some of the outcome variables were uncertain. The DREAM (Dynamic Research EvaluAtion for Managers 3.1) model (HarvestChoice 1995) was used to make initial assessments for the impact analysis around supply shifts and resulting price changes.

1 Other funders of the ACIAR projects (LWR2/1992/009 and LWR2/1996/143) were the University of Queensland, China Agriculture University, and another source not specified.

2 The 13 north-western provinces of China are: Beijing, Gansu, Henan, Hebei, Inner Mongolia, Liaoning, Ningxia, Qinghai, Shandong, Shaanxi, Shanxi, Tianjin and Xinjiang (Vere 2005).

Because of the uncertainty around the assumptions, Monte-Carlo simulation, using a triangular distribution (minimum, median and maximum), was applied to some of the variables. Triangular distribution is now one of the prescribed methods of conducting sensitivities around uncertain variables in the ACIAR guidelines (IAS 58).

Supply shifts, an adoption ceiling, and adoption lags were the variables that were subject to sensitivity analysis by Vere in applying this approach.

2.2.2 Summary of principal assumptions

China, with and without the ACIAR investment

Before the ACIAR projects, apart from some CT research conducted by China Agriculture University (CAU), there was little research or adoption of CT in north-western China. Vere (2005) noted that there was a Canadian project researching CT (with no links to CAU). The outcomes were not promoted, as the research was based in wetter cropping areas, different from the conditions of north-western China, and used heavy tillage equipment, not suitable for conditions in China.

Vere assumed that, due to the large volume of research being conducted globally, and with positive results being produced by the global research, adoption of CT in north-western China eventually would have taken place, even in the total absence of the ACIAR projects.

In summary, the 2005 analysis assumed that the benefits of CT technology in north-western China would have been realised 3 years earlier with the ACIAR project investment. Benefits were assumed to start 14 years after the beginning of the investments in the 'with' projects scenario, and 17 years in the 'without' projects scenario.

The adoption ceiling for wheat and maize in the north-west wheat/maize cropping area 'with' the projects was assumed 10%, and 'without' the projects was assumed 8%.

Table 1 provides a summary of assumptions for the China component from the 2005 assessment.

Australia, with and without the ACIAR investment

Vere noted that the projects did not claim to have originated the CTF system, but they (specifically LWR2/1992/009) had an important role in machine standardisation for CTF in Australia.

The two ACIAR projects did help demonstrate practical knowledge and usage of CTF within Australia, even though CTF was already in existence in other regions.

The impact assessment assigned benefits from the project specifically to southern Queensland and northern New South Wales dryland wheat growers. The 'with' project scenario assumed benefits from CTF research would have been brought forward 3 years, due to the ACIAR research in the base-case scenario.

A wheat yield increase of 10% due to CTF was assumed. The adoption ceiling with the projects was assumed to be 37% of the wheat area in the defined region 'with' the ACIAR investment, and 35% of the wheat area 'without' the ACIAR investment.

Benefits were assumed to begin 13 years after the start of the project in the 'with' project scenario, compared with 16 years after the project begun in the 'without' project scenario.

Table 1 provides a summary of assumptions for the Australia component from the 2005 assessment.

Table 1 Summary of principal assumptions in the original impact assessment

Variable	Australia—wheat	China—wheat	China—maize
Yield increase (%)	10.00	17.70	12.30
Cost saving (A$/ha)[(a)]	–4.00	26.60	93.60
Supply shift estimate (%)	9.70	10.50	11.40
Supply elasticity (regional)	0.30	0.25	0.26
Demand elasticity (regional)	–0.15	–0.28	–0.27
Adoption ceiling with project (%)	37.00	10.00	10.00
Adoption ceiling without project (%)	35.20	8.00	8.00
Adoption lag with project (years)	13.00	14.00	14.00
Adoption lag without project (years)	16.00	17.00	17.00

(a) It is assumed the cost saving in the Vere assumption is expressed in 2004–05 A$ terms.

2.3 Results of IAS 33

The overall benefit:cost ratio estimated from Vere (2005) for the investment in the two projects was 36.3:1, with a net present value of A$578.4 million. Though not stated explicitly in the report, the investment criteria were assumed to be in 2004–05 A$ terms, and calculated over 30 years from the first year of investment.

For a later comparison with the updated assessment, the net present value of A$578.4 million would be equivalent to A$837.9 million in 2018–19 terms.

The benefits were assumed to be captured by wheat producers in southern Queensland, northern New South Wales, north-western China, as well as consumers of wheat in Australia, China and the rest of the world. There were benefits also to maize producers in north-western China and consumers of maize in China and the rest of the world.

Due to supply shifts, and the resulting lower prices of wheat and maize assumed, there were stated to be losers from the ACIAR project investment. It was reported that wheat producers in other parts of Australia (excluding northern New South Wales and southern Queensland) and the rest of the world (excluding China) would suffer losses, due to lower world wheat prices caused by CTF adoption in Australia and others not adopting CTF.

Chinese wheat producers outside of the north-western provinces were reported as losing out due to non-adoption of CT technology (with international prices dropping due to Australian adoption of CTF). This interaction needed to be further explored in the updated assessment. For maize, producers in the rest of China and the rest of the world were reported to lose due to supply shifts (a result of lower prices).

Despite some negative surplus effects, the overall, global, annual surplus change was positive and estimated to be A$2,640.1 million.

Commentary on the 2005 assessment

The assumptions about the positive associations between the impacts of the ACIAR investment on adopting producers in both Australia and China appear acceptable. But the linkage between the impacts on adopters and non-adopters based on winners and losers and based on the international wheat and maize prices would appear to have some weakness in logic due to:

- the existence of winners and losers in different Australian regions linked through the advent of CTF-driven cost reductions in northern New South Wales and southern Queensland but not elsewhere in Australia—for example, where a cost-reducing technology is regionally specific and production regions vary sufficiently to have different production-cost structures, the new technology might increase production in one 'adopting' region, but not other 'non-adopting' regions, causing a supply shift and reducing the price for all regions; in such a case, non-adopting regions might suffer welfare losses as production falls in response to the new price (Vere 2005)
- the relationship between the marginal increase in the Australian supply of wheat in northern New South Wales and southern Queensland and the international price for wheat
- The existence of winners and losers in China, particularly from 2004 onwards, linked through market prices and production costs—this weakness was due to supply and demand models working ineffectively due to government involvement in the market through price floors for products and production subsidies associated with equipment and agricultural inputs.

3 Method

3.1 General methods

The Vere assessment of the ACIAR investments can be considered largely prospective, particularly with regard to outcomes and impacts. This is because the 2005 assessment was done just after the second ACIAR project was completed.

The current, updated analysis can be considered ex-post, as considerable outcome and impact information now exists some 14 years after completion of the second ACIAR project in 2003.

As with Vere's impact assessment, the two ACIAR projects are assessed jointly in the update, because the second ACIAR project (LWR2/1996/143) was a direct follow-on from the first ACIAR project (LWR2/1992/009).

The current impact assessment was conducted in line with the ACIAR impact assessment guidelines as set out in ACIAR IAS 58 (Davis et al. 2008). The ACIAR guidelines were not published when Vere undertook the original impact assessment of the ACIAR investments.

The current assessment process involved identifying and describing project objectives, activities, outputs, outcomes and impacts. The principal economic, environmental and social impacts identified were then summarised in a triple bottom line framework.

Some, but not all, of the impacts identified, were then valued in monetary terms. The impact assessment uses cost–benefit analysis as its principal tool. The decision not to value certain impacts identified was due either to:

- a shortage of necessary evidence/data
- a high degree of uncertainty surrounding the potential impact
- the likely low relative significance of the impact compared with those impacts that were valued—these include environmental and social impacts that are difficult to measure with accuracy.

The non-valued impacts are described qualitatively, so the impacts valued are deemed to represent the principal benefits delivered by the project. But, as not all impacts were valued, the investment criteria reported potentially represent an underestimate of the performance of the ACIAR investment.

The user groups assumed in the analysis are wheat farmers in Australia who gained from the CTF technology, and wheat and maize farmers in China who have adopted CT technology as a result of the two ACIAR projects.

The specific cost–benefit analysis methods used in the current assessment of impacts for both Australia and China vary somewhat from those in the earlier Vere impact assessment as explained in the following sections.

3.2 Comparison of methods used in 2005 and 2019

3.2.1 China

Methods used: Vere (2005)

The Vere (2005) analysis assumed regional and global price effects from the implementation of CT in China. For wheat, Vere assumed that the increased supply of wheat will only affect the Chinese wheat market (due to the assumption that the wheat market in China was a closed market).

The 2005 assessment also assumed that Chinese producers in non-adopting regions would be worse off due to lower international wheat prices from the Australian component of the ACIAR projects. So, the adoption of CT via impacts on increased supply was assumed to have affected global prices and have global distribution effects.

The maize price applicable to China producers was assumed as the global price, because China maize exports were almost 12% of world maize trade between 1998 and 2003 (Vere 2005). Currently, China exports less than 1% of its total maize production, and maize imports to China have been increasing (Index Mundi 2019).

When the initial impact assessment was done (2005), China was a net exporter of maize, so the assessment assumed that there would be global price effects from the impact of CT. Vere recognised that there may be internal taxes and subsidies, but internal taxes and subsidies were ignored for purposes of the impact assessment.

Commentary on the approach in the original assessment

Based on information obtained during the field trip, the literature reviewed, and other data gathered, it is reasonably assumed that for both wheat and maize in China, there have been significant government policy changes and intervention in the market that affects production costs and product prices, which both influence the production decisions of growers. Some of these policies might have been in place well before 2005, but major policy changes, particularly for maize, applied from about 2004.

Both maize and wheat producers in China receive various subsidies. For example, in Heilongjiang province (north-east China), maize had received a 133 Renminbi (RMB) per mu[3] subsidy in 2017, then a 33 RMB per mu subsidy in 2018 (Grain News 2018).

Also, there are price floors for wheat production (Dim Sums 2017; USDA 2019b) and minimum prices for maize of about 1,400 RMB per tonne (Dim Sums 2016b).

Additional production due to the adoption of CT would not lead to a consumer surplus and other non-adopting producers losing though a lower price, because of the floor price that would alleviate any price decline (Dim Sums 2016a).

While global prices might affect government decisions for maize and wheat, a floating market mechanism is not established to affect production decisions. So, for farmers in China, the global price might not affect their production decisions, unless the global price is higher than the price offered to them by the government.

Methods used: 2019 updated assessment

For the China component of the valuation for both wheat and maize, a producer surplus model is used in the updated impact assessment. The producer surplus model was considered most appropriate, as the beneficiaries of the ACIAR investments were producers who adopt CT technology.

China has minor wheat and maize exports and imports. In addition, supply and demand models might work inefficiently in China, due to government involvement in the market through price floors and production subsidies associated with equipment and inputs like seed.

So, the current analysis assumes that using global prices and elasticities to link China's supply and demand of wheat and maize to the rest of the world are not appropriate for the updated economic modelling.

An average exchange rate of 5 RMB to A$1 is used in the updated analysis. This was the exchange rate used in Vere (2005), and the exchange rate has not changed significantly since the original assessment (Reserve Bank of Australia 2019).

Due to the issues outlined, the impacts in China are valued via the net gains to the farmer from adopting CT. While there might be effects from subsidies on international growers and Chinese consumers, this is not taken into account, as these are not a part of the project or a result of the project.

Further valuing welfare distributional changes are likely to yield unreliable results, without taking into account further information on the availability and use of subsidies and other China Central Government interventions and how the ACIAR project impacts interacted with government policy decisions on subsidies.

3.2.2 Australia

Methods used: Vere (2005)

Influence on other regions

Vere assumed that there would be no adoption of CTF outside of southern Queensland and northern New South Wales, so wheat production in other Australian cropping regions would not benefit from lower costs of production, giving southern Queensland and northern New South Wales regions an advantage. This regional differentiation and its ramifications were translated into the subsequent economic modelling.

But while northern New South Wales and southern Queensland adoption of CTF was at the frontier of the technology development and use, other Australian regions (such as central Queensland) were also developing and using CTF. For example, Colin Dunne (Duaringa, central Queensland) reported:

> *I started planting up and back in rows in the 1980s and was using some minimum till practices. I realised I had a problem with soil compaction. The four wheel drive tractor was leaving big tracks, then I started to put the implement deeper which made it harder to pull and caused more wear and tear. I woke up one day and suddenly realised 'this is bloody ridiculous'. In 1998, I stopped ploughing, bought a spray rig and within 12 months, had totally adopted a zero till and a Controlled Traffic Farming System.*
>
> *Source: ACTFA (2014).*

Further, Land and Water Australia (2009) reported evaluations of the Queensland Department of Primary Industries project *Compaction control and repair practices for cropping lands in the sub-tropics* (QPI14). The project developed systems for CTF from 1992–93 to 1997–98, and was carried out by Dr Don Yule and Mr Bruce Radford of the Department of Primary Industries Queensland, Rockhampton.

3 Mu: a Chinese unit of land measurement. One mu is about equivalent to one 15th of a hectare (1 ha = 15 mu)

A graph in the report showed that, by 2003, the central Queensland area under CTF had increased to 100,000 ha. Also, it was reported that the central Queensland research and development project (QPI14), and contemporary research at the University of Queensland Gatton College (supported by funding from ACIAR and led by Dr Jeff Tullberg) were the precursors to considerable CTF research, development, extension and adoption elsewhere in Australia.

While the ACIAR projects and the central Queensland research could be considered to have an influence on some extent in the development of CTF in other Australian regions, the lag periods were variable, and many other factors contributed to CTF development across Australia.

With central Queensland and other Australian wheat farmers developing and using some form of CTF, the overall percentage of adoption of CTF in Australia attributable to the ACIAR investment might have been positive, but likely was relatively small. So, the gains driven by the ACIAR projects could be considered marginal in regions other than northern New South Wales and southern Queensland where the research was focused.

As a result, the assumption in the original assessment that the ACIAR investment would have increased wheat yield—lowering the cost of production per tonne and eliciting a supply response in the two project target regions but not in other Australian regions—was considered questionable.

Influence on world prices

The original assessment appears to make an explicit assumption that world wheat prices and wheat price formation in Australia are strongly influenced by the level of Australian production. Though this may be true in particular circumstances, for example, situations of drought and/or feed grain shortage, it is not the norm. The wheat price assumption is unlikely to hold when considering price effects only based on production volumes from select regions in Australia, such as southern Queensland and northern New South Wales.

So, while significant for individual producers in northern New South Wales and southern Queensland, the increased production in those regions would have been unlikely to have affected global wheat prices.

Methods used: 2019 updated assessment

A producer surplus model was used in the current assessment of impacts for Australia. This captures the benefits to adopters of CTF in Australia that could be attributed to the investment in the two ACIAR projects. The increase in yield and associated cost reduction as a result of adopting CTF are assumed to drive the estimated economic surplus captured by producers.

The producer surplus method will capture the benefits of the project to farmers who adopted CTF in southern Queensland and northern New South Wales primarily, with the possibility of some potential, but non-quantified, impacts on the rate of development of CTF in other Australian cropping regions.

3.3 Other method issues

3.3.1 Counterfactual

Vere (2005) Assessment

China

Vere (2005) assumed that the primary impact of the investment was that the ACIAR projects brought forward the adoption of CT in China's north-western provinces by 3 years. Further, Vere assumed that the maximum level of CT adoption in north-western China would be higher with the projects. So, the counterfactual scenario was that CT would have been adopted later and at a lower level without the ACIAR investment.

Australia

A similar counterfactual was assumed for the impact of CTF in Australia. Vere (2005) assumed that, without the ACIAR projects, adoption of CTF would have lagged 3 years in Queensland and northern New South Wales, and that the adoption ceiling for CTF would have been lower.

2019 updated assessment

China

The counterfactual was a key area of enquiry during the evaluation team's field trip to China in 2019. A number of CT researchers, government representatives and industry personnel were consulted to probe the validity of the original 'without investment' assumptions used in the 2005 impact assessment. The evaluation team found that all of the stakeholders consulted agreed that, without the ACIAR projects, CT adoption would have occurred later in China. But the consensus was that a 3-year time lag was too conservative, and that it was more likely that, without the ACIAR projects that generated significant government support for CT research and adoption, CT adoption would not have occurred for at least 10 years.

Further, the evaluation team found little evidence to support the notion that the maximum level of CT adoption would be reduced without the ACIAR investment. Specific details for the valuation of impacts in the updated impact assessment are described in Section 8.

Australia

Updated data and consultation with Dr Jeff Tullberg and staff at the Australian Grains Research and Development Corporation indicated that the original counterfactual used in the 2005 impact assessment was largely valid.

So, the 2019 assessment assumed a 3-year time lag for adoption of CTF in Queensland and northern New South Wales. But it was assumed that the maximum adoption level of CTF would be the same both with and without the ACIAR investment. Specific details for the valuation of impacts in the updated impact assessment are described in Section 8.

3.3.2 Attribution

Vere (2005) assessment

Based on the assumptions made and the counterfactual scenarios used, Vere (2005) assumed that all of the benefits estimated for CT in China, and for CTF in Australia, were attributable to the ACIAR investment.

2019 updated assessment

Interrogation of the assumptions used in the 2005 impact assessment, updated data and consultation with key CT/CTF stakeholders indicated that the attribution of benefits assumed in the original impact assessment was valid. So, the current assessment also assumed that all benefits estimated for CT in China, and for CTF in Australia, were attributable to the ACIAR investment.

Given that the primary impact valued for the ACIAR investment is associated with a time lag where the adoption of CT/CTF would have occurred later without the investment, the attribution implies that 100% of the benefits of this time period shift are attributable to the ACIAR projects. Specific details for the valuation of impacts in the updated impact assessment are described in Section 8.

4 Project investment

Investment in the two projects was carried out over a 10-year period from 1992–93 to 2002–03. In each of the two projects, time extensions were approved (2 years for LWR2/1992/009 and 3 years for LWR2/1996/143).

Table 2 presents the funding by year and by funding contributor for each of the ACIAR projects. All values in Table 2 are in nominal A$ terms.

Table 2 Investment in the ACIAR projects, by year and funding contributor

	Funding contributor				
Year	**ACIAR**	**University of Queensland**	**CAU**	**Other**	**Total**
Project LWR2/1992/009					
1992–93	58,298	39,850	30,150	0	128,298
1993–94	173,722	80,200	60,300	0	314,222
1994–95	137,391	81,200	61,500	0	280,091
1995–96	82,882	40,850	31,350	0	155,082
Total	*452,293*	*242,100*	*183,300*	*0*	*877,693*
Project LWR2/1992/009 extension					
1995–96	34,756	45,671	0	0	80,427
1996–97	22,956	43,067	0	0	66,023
Total	*57,712*	*88,738*	*0*	*0*	*146,450*
Total project LWR2/1992/009	**510,005**	**330,838**	**183,300**	**0**	**1,024,143**
Project LWR2/1996/143					
1997–98	291,826	168,124	123,148	22,503	605,601
1998–99	260,512	168,124	101,491	22,503	552,630
1999–2000	243,228	168,124	95,835	22,503	529,690
Total	*795,566*	*504,372*	*320,474*	*67,509*	*1,687,921*
Project LWR2/1996/143 extension					
2000–01	48,820	10,600	22,850	0	82,270
2001–02	49,795	10,600	18,000	0	78,395
2002–03	24,955	6,900	7,000	0	38,855
Total	*123,570*	*28,100*	*47,850*	*0*	*199,520*
Total LWR2/1996/143	**919,136**	**532,472**	**368,324**	**67,509**	**1,887,441**
Total—all projects and extensions	**1,429,141**	**863,310**	**551,624**	**67,509**	**2,911,584**

5 Logical framework

The 2019 logical framework used to conduct the 2019 assessment is based on:

- information gathered during the scoping study
- information and data gathered from the field trip
- consultation with researchers
- a number of other sources.

The updated information, assembled since the original 2005 assessment was completed, provides more detail on the original objectives of the two ACIAR projects, and includes new information and statistical data that refer mostly to 2003–18.

This new information has been used in the current assessment, along with some changes to the earlier valuation methods and assumptions used to value impacts in the original assessment.

5.1 Project details: summary

The two ACIAR projects had several objectives, which were broken down into specific objectives for Australia and China, and joint objectives.

5.1.1 Objectives of LWR2/1992/009

The objectives for the Australian component were to:

- develop a low-power, controlled-traffic CT system for wheat production
- evaluate traffic effects on soil and crop performance under three surface-management regimes
- develop grain production technology to minimise inputs of energy and herbicides
- assess the potential for the use of controlled-traffic zero-tillage systems based on 'gantry' units or modified conventional equipment in sustainable crop production systems that lead to long-term resource conservation.

The objectives for the China component were to:

- assess the suitability of various Australian equipment and residue treatment methods for CT in north-western China
- identify appropriate CT systems for wheat and maize production and to develop assessment techniques
- evaluate CT systems in terms of energy requirements, residue retention, soil moisture storage and crop yields
- assess the effects of deep tillage and traffic on soil moisture storage capacity.

5.1.2 Objectives of project LWR2/1996/143

The objectives for the Australian component were to:

- measure soil and crop response to wheel traffic within different tillage systems, and use these data to calibrate a field-plot-scale simulation model
- investigate wheel track persistence in cropped soil, and examine soil deformation under wheels, to provide a basis for modelling random traffic effects
- assess cropping system developments made possible at varying levels of machine/crop precision.

The objectives for the China component were to:

- assess the effects of crop residue, soil tillage and wheel traffic on soil properties, and the growth of wheat and maize in Shanxi Province, as well as the scope to generalise findings via simulation modelling
- further develop CT equipment and systems, and assess their potential for incorporation into economically and socially viable farm-scale systems
- develop a pilot program to build local capability and expand research to sloping land in the water-erosion-affected areas of western Shanxi, and to the more arid regions.

Joint objectives for both China and Australia components were to:

- assess the scope for simulation models to examine and generalise the impact of mechanised CT, through modifying, calibrating and validating existing models using data from both countries
- assess the operation of CT and CTF systems to determine their effect on labour/machine operating costs, ownership (fixed) costs and timeliness
- compare the economic advantages of precision CTF systems involving fewer, less energy-intensive operations, with conventional crop-production systems, within a benefit–cost framework using results from crop simulation modelling, appropriate soils and management information, and long-term weather data.

5.2 Project activities: overview

- The projects undertook winter wheat trials at sites at Chenghuang Village, Linfen, Shanxi, and maize trails at Shouyang, Shanxi. The trial sites were difficult to source, with other more suitable sites not available for trials due to lack of interest (Li Hongwen pers. comm. 2019).
- One set of experiments used three treatments in five randomised blocks, two CTF treatments with full straw cover (shallow tillage and zero tillage), and one conventional tillage treatment (Chen et al. 2008). Soil sampling was taken at the sites, and water retention was measured.
- When the initial LWR2/1992/009 project was completed, it was noted that the CT technology produced was not ready for adoption in China. So, a 1-year extension was funded to make further progress in assessing appropriate CT technologies and evaluating CT systems in terms of energy use, and assessing the effects of tillage and traffic on soil moisture. The second project also was funded (LWR2/1996/143) so CT systems could be further developed, ready for adoption.
- The experimental site at University of Queensland, Gatton, was used from 1993 to 1996, with the experiment continuing until 1999 (Li et al. 2007). A layout of control traffic plots was developed, with equipment restricted to permanent lanes. There were multiple treatments at the Gatton site, with CTF (both with zero tillage and stubble mulch) and wheeled (zero tillage and stubble mulch).
- A single field experiment was carried out at Gatton during the second project.
- During the second project (LWR2/1996), there was a continuation of trials at Linfen in China.
- Replicated plots were established in 1998 to assess component effects on wheat and maize production in China. The experiments tested the effect of wheel traffic.
- The Australian trials extended over 5 years from 1996, with three summer and four winter crops.

5.3 Project outputs

5.3.1 China

- The first trials (in LWR2/1992/009) at Linfen (Shanxi) found that if no-till standing straw is excluded, yields for the four treatments (including subsoiling with chopped straw, no-till with chopped straw, subsoiling with pressed straw and no-till with standing straw) increased by an average of 21% over the traditional control treatment, varying from a 12% to a 32% increase.
- From the plots established at Linfen in 1993, CT increased the mean yields over conventional tillage by 22% for winter wheat and 15% for spring maize.
- In 3 of the 8 years of trials, CTF treatments provided higher yields than conventional tillage, with yield increases of almost 11% (Chen et al. 2008).
- The project showed that CT (zero till, minimum till), and CTF increased soil organic carbon and microbial biomass carbon (Chen et al. 2008).
- During the ACIAR projects, there was an issue that the tractors used in China did not have the lifting capacity for weight-dependent disk openers used for zero tillage. Subsequent investment in machinery and research has solved the problem, with improved machinery being built for Chinese conditions by Chinese companies.

5.3.2 Australia

- CTF research at University of Queensland, Gatton, increased winter wheat yields on average by 15% compared with other CT systems.
- In the Australian trials, wheeled traffic and tillage were shown to increase runoff, mainly in dry years (Li et al. 2007).
- From 1994 to 1999, at plots at University of Queensland, Gatton, summer grain yield for CTF was almost 8% higher than wheeled plots (Li et al. 2007).
- For CTF, average winter yields were 12% higher than wheeled treatments.
- Yields for wheat at Gatton increased on average by 11%, excluding subsoiling with standing straw, as this treatment failed, due to problems with ground temperature and seeding quality.

5.4 Key outcomes

Several outcomes have followed the activities and findings of the two ACIAR projects. For China, the important outcomes are drawn from:

- the original assessment
- the scoping study
- information assembled from the field trip in China in July 2019 (see Appendix 1 for further detail).

For Australia, the outcomes are derived from:

- the original assessment
- the scoping study and discussions held with Dr Jeff Tullberg (pers. comm. to Peter Chudleigh 2019) in Australia during 2019.

5.4.1 China

- Due to the results of the ACIAR projects, there has been a conversion of wheat and maize production from conventional tillage to CT in erosion-prone areas in the Loess Plateau (Vere 2005).
- As of 2004, there were 20 no-till planter factories in China as a result of the uptake of CT (Vere 2005).
- In 2002, there was a visit to the trial sites by the Chinese Ministry of Agriculture (MoA), including the Vice Minister of Agriculture. As a result of these visits, there was a directive by the MoA to prepare a national CT extension plan in that year.
- The ACIAR projects have informed and influenced subsequent research and policy direction in China, including increased investment in CT extension and in further research by the MoA.
- As a result of the two ACIAR projects, there have been several policy changes in China. For example, CT has been a key part of the Agriculture component of the 10th five-year plan (2002–05), and has been recognised as a key technology by the then Premier Wen Jiabao.
- With the increased interest in CT, there was a higher demand for appropriate machinery. Under the MoA, some government subsidies have been available to support the development of appropriate CT machinery and its subsequent purchase by farmers. Also, the Conservation Tillage Centre has been developing further specific machinery for use in CT. For example, there has been further development of Chinese-developed minimum and no-tillage seeders and planters.
- The government policy changes, and machinery developments have supported and influenced the adoption level of CT in China.

- The CT development and the role played by the ACIAR investment have been recognised by the China Central Government and MoA. Several awards were presented to the research team including:
  - 2nd class National Science and Technology progress award, presented to Professor Gao in January 2003 (second highest science award in China)
  - 11 other national science and technology awards (He Jin pers. comm. 2019)
  - Friendship and Cooperation award presented to Dr Jeff Tullberg from the Foreign Experts Bureau of China in November 2001.
- Vere (2005) noted from unpublished studies by Gao Huanwen that in 2004, 220,000 hectares of wheat and maize were cultivated under CT.
- Additionally, the CT area in China has now grown from 0.58 million hectares in 2005 to 7.58 million hectares in 2017.
- The MoA planned for 2 million hectares of government supported CT by 2015 (Vere 2005). It was reported during the field trip that this target has been reached and exceeded.
- As of 2005, there were 10 PhD and Master students involved with CT research at CAU, with other universities in Hebei and Shanxi also involved with CT research. There are now a number of students studying conservation agriculture (and CT), due to the increased interest in CT.
- Expertise built through LWR2/1992/009 and LWR2/1996/143 assisted the development and implementation of ACIAR project LWR2/2002/094 (*Promotion of conservation agriculture using permanent raised beds in irrigated cropping in the Hexi Corridor, Gansu, China*).
- There is lower farm labour usage on farms because of increased use of CT.
- Post-2005 extension efforts associated with CT have taken place—for example, a book directed at farmers has been produced by Li Hongwen aiming to inform farmers of the methods of CT (Li et al. 2015).
- As government was investing in CT, and CAU had increased research capacity, private firms were able to be established to provide seeders and other CT equipment to support the ongoing development of CT and other sustainable agricultural practices in China. Without the ACIAR projects and subsequent investment as a result of the projects, it is likely that these private companies would not have been established. Visits to Debont and Nonghaha, and the associated discussions held, confirmed that without government support for CT, the private companies would probably not exist (Wu Yuntao pers. comm. 2019).
- From the China CT Network (an extension of the CT Research Centre of the MoA), there have been 110 patents under development, with technology development mainly by Chinese members of the ACIAR project team. Some of these patents will relate to outputs of the ACIAR research previously conducted (Li Hongwen pers. comm. 2019).
- There is a plan for 60% adoption of CT by 2022 in the north-east region (Liaoning, Jilin, Heilongjiang, and north-east Inner Mongolia) (Li Hongwen pers. comm. 2019).
- Across China, it is now illegal to burn straw residue from tillage, reducing previous negative environmental impacts.
- The United Nations Economic and Social Commission for Asia and the Pacific body, the Centre for Sustainable Agricultural Mechanization (CSAM), set up its main office in Beijing. One of the reasons for choosing Beijing was the capacity of the CAU team (Macro Silvestri pers. comm. 2019).

5.4.2 Australia

- The ACIAR research increased the knowledge available for CTF. The projects enabled further evidence of CTF benefits on southern Queensland and northern New South Wales farms.
- The ACIAR projects, together with other initiatives, have contributed in part to the increased adoption of CTF in Australia. But the adoption of CT in Australia was assumed not to have changed as the University of Queensland Gatton research focused on CTF and the additional benefits of CTF over CT.
- The project has led to CTF being viewed from a specialised practice to a more mainstream farm practice (Jeff Tullberg pers. comm. 2019).
- CTF conference papers have used and communicated results from the ACIAR projects, enabling Australian cropping farmers to be better informed of the benefits of using CTF.

6 Impacts (China and Australia)

Vere (2005) found that the main impacts of the ACIAR-funded projects were to:

- speed up the delivery and adoption of CT into China for dryland wheat and maize production in the north-western provinces
- intensify CTF research in the project areas in Australia through the provision of additional research funds, which brought forward the delivery of research outcomes.

The current analysis confirmed Vere's finding that the key impact of the ACIAR projects was bringing forward the delivery of CTF outcomes in Australia and speeding up the adoption of CT practices in China. The major impacts resulting from these outcomes have been:

- increased yield of wheat for cropping farmers in southern Queensland and northern New South Wales
- increased yield and lowered costs for wheat and maize in the north of China through adoption of CT practices.

There have also been major environmental and natural resource management impacts in both countries. These include reduced soil erosion, reduced wind erosion, increased soil moisture holding capacity, increased carbon sequestration via higher crop yields, less air pollution from straw burning, and lower greenhouse gas emissions.

On the other hand, there might have been some negative environmental impacts through increased pesticide use.

The ACIAR projects also had social impacts in China. While there was not a large gender effect, feedback from stakeholders during the field trip indicated that there had been a labour-saving impact, with a reduced need for labour from older people.

In addition, due to CT and CT machinery companies being based in rural areas, adoption of CT in China has created career opportunities for local workers to stay in their hometowns and local regions.

The project also yielded significant capacity-building impacts, through greater training and research capacity in CT. A secondary impact is that the increased Chinese training and research capacity has led to direct impacts in other Asian and African countries, due to further Chinese extension and teaching of CT in these countries, often through joint research, development and extension activities.

7 Updated valuation of impacts

7.1 China: impact valuation framework, data and assumptions

7.1.1 Overview

For the updated impact assessment, all financial values are expressed in 2018–19 A$ terms. The two principal impacts that are valued in the updated impact assessment were the:

- lowered costs of production (reduced labour, fuel, water and fertiliser inputs)
- yield increase related to the adoption of CT as driven by the ACIAR investment.

So, this valuation needed:

- identification of the relevant crop growing region (or regions) where CT adoption has taken place in China since 2003
- the area under CT by year for each of the crops of wheat and maize
- productivity gains due to CT, such as the yield increase per mu or per ha for wheat and maize, and the value of the saved costs of production per mu or per ha for wheat and maize
- identification of any additional costs incurred in China that may have enhanced adoption of CT after the ACIAR projects and that would not have been included in the original assessment
- the counterfactual scenario associated with what would have been the likely development of CT without the ACIAR projects having been funded over the 1992–2003 period.

7.1.2 Relevant crop growing regions for CT adoption

The crop growing regions of China that were influenced by the ACIAR investment included some provinces and autonomous regions in the north-west, the northern plains and the north-east. The 13 provinces included:

1. Beijing (north-east)
2. Gansu (northern plains)
3. Henan (north-east)
4. Hebei (north-east)
5. Inner Mongolia (north-east)
6. Liaoning (north-east)
7. Ningxia (northern plains)
8. Qinghai (north-west)
9. Shandong (north-east)
10. Shaanxi (north-east)
11. Shanxi (north-east)
12. Tianjin (north-east)
13. Xinjiang (north-west).

7.1.3 Area of wheat and maize in the regions where CT was adopted

Table 3 provides the total area of wheat and maize by year in the CT-relevant regions in northern China. In 1992–2018:

- the area of wheat in the CT-relevant regions averaged 33% of the total area of wheat in China
- the relevant CT regions for maize averaged 56% of the total maize area in China.

7.1.4 Area of CT farming in China

Table 4 presents the total area adopting CT in China from 1992 to 2017.

Actual data for specific adoption levels of CT by region or by crop type for China were not readily available. So, estimates were made based on the total CT area percentage by year, and then partitioned by crop type according to the total area of each crop in the each of the 13 provinces. Such estimates of CT area by crop were required to apply the differential yield increases for wheat and maize, and to estimate the production and value increases for each year (Table 5).

7.1.5 Value of productivity gains

Adopting CT for wheat and maize has provided some wheat and maize farmers in China with increased yields, as well as production cost savings and improved environmental outcomes.

The value of these gains is dependent on the region and the crop grown, but has not been able to be estimated by region. Instead, Table 6 provides average estimates of the yield, and cost-saving benefits delivered from the adoption of CT across northern China. It also includes some additional demonstration, training and extension costs incurred by local and central governments in China to promote CT after the ACIAR projects were completed.

Table 3 Area of wheat and maize in relevant CT regions (China), by year, 1992–2018

Year	Area of wheat (ha)	Area of maize (ha)	Total area of wheat and maize (ha)
1992	11,714,600	11,384,400	23,099,000
1993	11,344,100	10,933,400	22,277,500
1994	10,564,400	11,299,000	21,863,400
1995	10,526,200	12,473,300	22,999,500
1996	10,890,850	12,222,050	23,112,900
1997	10,779,690	13,432,560	24,212,250
1998	10,606,640	14,006,520	24,613,160
1999	10,760,100	14,006,600	24,766,700
2000	10,223,200	14,483,000	24,706,200
2001	9,244,000	12,295,600	21,539,600
2002	8,239,800	13,482,700	21,722,500
2003	7,888,900	13,723,200	21,612,100
2004	6,899,400	13,394,500	20,293,900
2005	6,788,100	14,582,500	21,370,600
2006	7,313,500	15,000,700	22,314,200
2007	7,260,400	15,489,500	22,749,900
2008	7,175,400	17,566,800	24,742,200
2009	7,080,100	17,777,900	24,858,000
2010	7,713,400	19,705,500	27,418,900
2011	7,639,200	19,777,300	27,416,500
2012	7,524,800	20,513,900	28,038,700
2013	7,406,500	21,739,300	29,145,800
2014	7,183,300	22,796,200	29,979,500
2015	7,100,200	23,359,100	30,459,300
2016	7,095,500	24,118,200	31,213,700
2017	7,139,600	22,834,700	29,974,300
2018	6,927,600	25,620,200	32,547,800

Source: National Bureau of Statistics of China (2018)

Table 4 Adoption of CT in China, by year, 1992–2017

Year	Area of CT (ha)	Area of CT (mu)[(a)]	Area of CT as percentage of total wheat and maize cropping area (%)
1992	0	0	0.00
1993	1,333	19,995	0.01
1994	4,000	60,000	0.02
1995	8,000	120,000	0.03
1996	10,000	150,000	0.04
1997	12,000	180,000	0.05
1998	13,333	199,995	0.05
1999	26,667	400,005	0.11
2000	66,667	1,000,005	0.27
2001	80,000	1,200,000	0.37
2002	101,333	1,519,995	0.47
2003	261,333	3,919,995	1.21
2004	410,667	6,160,005	2.02
2005	577,333	8,659,995	2.70
2006	530,000	7,950,000	2.38
2007	2,041,333	30,619,995	8.97
2008	2,985,340	44,780,100	12.07
2009	3,506,550	52,598,250	14.11
2010	4,316,850	64,752,750	15.74
2011	5,715,530	85,732,950	20.85
2012	6,451,270	96,769,050	23.01
2013	7,731,360	115,970,400	26.53
2014	8,622,800	129,342,000	28.76
2015	9,337,980	140,069,700	30.66
2016	8,684,270	130,264,050	27.82
2017	7,584,440	113,766,600	25.30

Source: Data provided by CAU, from China Agricultural Statistics.

(a) 1 ha = 15 mu.

Table 5 Estimated area of CT cropping in China, by crop type and year, 1992–2018

Year	Area of wheat grown with CT (ha)	Area of maize grown with CT (ha)	Total crop area grown under CT (ha)
1992	0	0	0
1993	679	654	1,333
1994	1,933	2,067	4,000
1995	3,661	4,339	8,000
1996	4,712	5,288	10,000
1997	5,343	6,657	12,000
1998	5,746	7,587	13,333
1999	11,586	15,081	26,667
2000	27,586	39,081	66,667
2001	34,333	45,667	80,000
2002	38,438	62,895	101,333
2003	95,392	165,941	261,333
2004	139,616	271,051	410,667
2005	183,383	393,950	577,333
2006	173,708	356,292	530,000
2007	651,471	1,389,862	2,041,333
2008	865,768	2,119,572	2,985,340
2009	998,742	2,507,808	3,506,550
2010	1,214,403	3,102,447	4,316,850
2011	1,592,547	4,122,983	5,715,530
2012	1,731,340	4,719,930	6,451,270
2013	1,964,685	5,766,675	7,731,360
2014	2,066,084	6,556,716	8,622,800
2015	2,176,725	7,161,255	9,337,980
2016	1,974,109	6,710,161	8,684,270
2017	1,806,543	5,777,897	7,584,440
2018[a]	1,752,901	6,482,716	8,235,616

Source: Estimated by Agtrans Research.

(a) Based on proportion of total wheat and maize area under CT for 2017 of 25.3%.

Table 6 Assumptions for productivity gains in China

Variable	Assumption	Source
Additional yields and reduced costs attributed to CT		
Average yield for wheat (without CT)	3.4 tonnes per ha	Average for the 13 CT regions 1990–92, before the ACIAR projects and significant adoption of CT in China (derived from data provided by CAU based on published China Agricultural Statistics)
Average yield for maize (without CT)	4.7 tonnes per ha	
Average yield increase for wheat in northern China due to CT	7.5%	Hongwen et al. 2015
Average yield increase for maize in northern China due to CT	5.8%	Hongwen et al. 2015
Forecast total area of CT in 2019–23 as a proportion of the total area of wheat and maize in northern China	25.3% in 2018 increasing linearly to 40% in 2023	Wang Guozhan pers. comm. 2019 & Li Hongwen pers. comm. 2019 Based on government expenditure on CT extension with targets for north-eastern China of 60% CT adoption and 30% CT adoption in the rest of northern China by 2023
Total area of wheat and maize grown in northern China in 2019–23	32,547,800 ha per annum (assumed to remain constant at the 2018 level)	See Table 3
Value of wheat (estimated farm gate)	1,900 RMB per tonne	SunSirs Commodity Group 2019 www.sunsirs.com/uk/prodetail-349.html Adjusted for freight
Value of maize (farm gate)	1,600 RMB per tonne	USDA 2019c
Exchange rate	5 RMB per A$	Reserve Bank of Australia 2019
Total average cost savings	63 RMB per mu (equivalent to A$189/ha)	He Jin pers. comm. 2019; Li Hongwen pers. comm. 2019
Total average cost savings are made up of:		
Labour savings	3 to 5 persons annually per mu	China Agricultural Machinery Testing Centre pers. comm. 2019
Fuel savings	3.2 L per mu	
Water saving	36–65 m^3 per mu	
Chemical fertiliser savings	10%	
Additional costs by governments in China after the ACIAR projects		
Demonstration and training (Central Government)	100 million RMB per annum in 2002–12	Wang Guozhan pers. comm. 2019
Support of extension (local governments)	30 million RMB per annum in 2012–19, then 36 million RMB per annum in 2020–23	Wang Guozhan pers. comm. 2019
Additional costs of using CT		
Capital cost of machinery	Any additional costs of using CT have been assumed to be zero, as it was assumed that mechanisation of machinery was occurring anyway, and investment in other machinery of equivalent value (such as conventional tillage mechanisation) would have occurred without the ACIAR CT investment.	
Timing of impact		
Start of adoption/benefits with ACIAR projects	1993	Based on first year of adoption of CT in China (CAU, from China Agricultural Statistics, see Table 5)
Start of adoption/benefits without ACIAR projects	2003	Based on 10-year lag estimated via consultation with various government, industry and research personnel in China during the field trip in 2019

Note: For further information on the sources of key assumptions and validation of assumptions and data, refer to Appendix 1.

7.1.6 Additional costs incurred by governments in China

Since the second project was completed (2003) there has been further support provided within China in the form of machinery development and input subsidies to cropping farmers. Table 7 lists some of the additional funding provided to cropping farmers. As distinct to the direct government support already included in Table 6, the support in Table 7 was not directly targeted at CT, but had a wider purpose and would have occurred anyway in the absence of the ACIAR project investment.

The initial ACIAR project findings gave confidence to the China Central Government to further support and invest in CT (Li Hongwen pers comm. 2019; Wang Guozhan pers comm. 2019).

A total of 30 million RMB per year was confirmed for further extension of CT from 2012 to 2019, with an additional 6 million RMB (36 million RMB per annum total) from 2020 to at least 2023 to support increased adoption of CT in north-eastern China.

7.1.7 Counterfactual

Without the ACIAR investment, investment in CT technology in China would have been significantly delayed. The assumption for the counterfactual is that without the ACIAR investment, the delay in CT investment and support in promoting CT would have had been at least 10 years. This assumption was supported by information provided through consultation with various government, industry and research personnel in China during the field trip.

In support of this assumption, it was reported that around the year 2000, external environmental factors, such as major dust storms that affected China's capital (Beijing), would have prompted investment in CT research, development and extension (Li Hongwen pers comm. 2019).

While other countries were potentially looking at supporting CT research in China, most of the interest came after the ACIAR projects started and preliminary positive results were obtained from the projects (Li Hongwen pers. comm. 2019).

Further, consultation with government officials in China indicated that the success of the ACIAR projects in terms of promoting CT adoption in China came through the long-term nature of the investment, which enabled researchers to demonstrate the benefits of CT to industry and government, and start the work required to develop machinery to support CT adoption. So, it is likely that, without the ACIAR projects, there would have been no other funders of significant CT research in China for some time.

7.1.8 Impacts not valued

Some impacts for China, identified earlier in the earlier logical framework (Section 5), were not valued in the updated impact assessment.

Environmental and natural resource management impacts

Positive impacts included:

- reduced soil erosion
- lowered frequency of dust storms
- improved air quality and lowered greenhouse gas emissions from reduced straw burning
- increased crop yields
- increased soil moisture holding capacity.

Potential negatives impacts included some increased pesticide use.

Social impacts

Positive impacts included:

- labour savings on farm of between 3 and 5 people per mu, so a reduced need for agricultural labour particularly from older people
- increased employment for machine manufacture in regional areas
- capability and capacity building via training opportunities
- the economic, environmental and social impacts from extension and teaching from Chinese personnel in other countries.

Table 7 Additional support provided to indirectly enhance CT adoption post-ACIAR projects

Funder	Reasons for support funds	Value (RMB)	Years	Source
Central and local governments	Unspecified	3.6 billion RMB total	2009	Li Hongwen pers. comm. 2019
Central Government	Sustainable farming (not exclusive CT)	2 billion RMB total	2018–current	Wang Guozhan pers. comm. 2019
Central Government	Machinery purchasing	1.2 billion RMB total	2009–12	Wang Guozhan pers. comm. 2019

The reasons for non-valuation of these impacts included:

- the lack of and complexity of identifying the pathways to impact
- the difficulty in assigning credible values to the assumptions associated with each of the non-valued impacts identified
- the resources and time available for additional assessment.

Further, some of these non-valued impacts might have been included already, indirectly, in the impacts valued (for example, soil moisture holding leading to crop yield increases).

7.2 Australia: impact valuation framework, data and assumptions

7.2.1 Overview

For the updated Australian impact assessment, all financial values are expressed in 2018–19 A$ terms. One principal impact is valued in the updated assessment of impacts in Australia: the increase in wheat yield, taking into account the additional costs related to the use of CTF.

This required assumptions to identify the:

- relevant crop growing region (or regions) where CTF adoption has taken place due to the ACIAR investments
- area where wheat is grown in the relevant regions by year
- productivity gains due to use of CTF
- yield increase that could be attributed to the original ACIAR investments
- counterfactual scenario associated with what would have been the likely development of CTF without the ACIAR investment for the projects over 1992–2003.

7.2.2 Relevant crop growing regions for CTF adoption

The crop growing regions of Australia that were significantly influenced by the ACIAR investments were the wheat growing areas of northern New South Wales and southern Queensland.

While there was potentially some influence on the adoption of CTF in other Australian wheat growing areas, this is assumed to have been offset by the influence of CTF research in other Australian cropping areas on the regions where the ACIAR projects were focused.

7.2.3 Area of wheat in the two target regions

The area of wheat in southern Queensland over time is assumed to be an average of 80% of the total Queensland area of wheat. This assumes that 50% of the total Queensland wheat area is in the south-east (for example, Darling Downs) and 30% is in the south-west (for example, Maranoa), with the remainder mostly in central Queensland.

The area of wheat in northern New South Wales has been assumed to be 37% of the total New South Wales area (17% in the north-east and 20% in the north-west).

As the statistical definitions of the target regions of northern New South Wales and southern Queensland were not specified, the percentage estimates were based on Australian Bureau of Statistics (ABS) regional statistical data and Agtrans' knowledge of wheat area distribution in each state.

Table 8 provides estimates of the area of wheat in each of the two regions from 1995.

7.2.4 Area of CTF in Australia

Relevant data for adoption of CTF usage by agroecological zones are available from Grains Research and Development Corporation surveys every 2–3 years starting in 2008. The available agroecological zones percentages have been combined to state level by Agtrans Research for the years ending June 2008, 2011, 2014 and 2016. Also, it was assumed that CTF adoption across Australia was close to zero in 1995, confirmed by discussions with Dr Jeff Tullberg (pers. comm. 2019). Linear interpolation between the survey data points was then used to populate estimates by year for 1995–2016.

Table 9 presents the estimated CTF percentage adoption by state.

Table 10 presents the estimated CTF percentages by year for the two target regions in New South Wales and Queensland, based on information in Tables 8 and 9.

Table 8 Area of wheat in northern New South Wales and southern Queensland, by year, 1995–2018

Year (ended June)	Qld wheat area (ha)	Estimated southern Qld wheat area (ha)	NSW wheat area (ha)	Estimated northern NSW wheat area (ha)
1994–95	401,000	320,800	1,424,000	526,880
1995–96	627,000	501,600	2,328,000	861,360
1996–97	980,999	784,799	3,192,000	1,181,040
1997–98	999,000	799,200	2,936,000	1,086,320
1998–99	1,139,000	911,200	3,174,000	1,174,380
1999–2000	1,096,000	876,800	3,425,000	1,267,250
2000–01	885,000	708,000	3,671,000	1,358,270
2001–02	604,000	483,200	3,446,000	1,275,020
2002–03	514,000	411,200	2,995,000	1,108,150
2003–04	790,000	632,000	3,983,000	1,473,710
2004–05	711,000	568,800	4,256,000	1,574,720
2005–06	778,000	622,400	3,554,000	1,314,980
2006–07	638,000	510,400	3,596,000	1,330,520
2007–08	669,000	535,200	4,009,000	1,483,330
2008–09	1,020,000	816,000	4,322,000	1,599,140
2009–10	962,000	769,600	3,983,000	1,473,710
2010–11	906,000	724,800	3,815,000	1,411,550
2011–12	953,000	762,400	3,868,000	1,431,160
2012–13	866,000	692,800	3,487,000	1,290,190
2013–14	758,000	606,400	3,269,000	1,209,530
2014–15	634,000	507,200	3,166,000	1,171,420
2015–16	611,000	488,800	2,933,000	1,085,210
2016–17	622,000	497,600	3,248,000	1,201,760
2017–18	610,000	488,000	3,100,000	1,147,000

Source: Australian Bureau of Agricultural and Resource Economics (ABARES) Australian Commodity Statistics (various issues) for state data; Agtrans Research for southern Queensland and northern New South Wales percentage estimates.

Table 9 Estimates of adoption of CTF by Australian state, by year and state, 1995–2016

Year	Percentage of adoption of CTF, by state[a]					
	Qld	NSW	Vic	SA	WA	Tas
1995[b]	0.0	0.0	0.0	0.0	0.0	0.0
1996	2.8	1.4	0.8	0.6	0.3	1.0
1997	5.6	2.8	1.6	1.1	0.7	1.9
1998	8.4	4.1	2.4	1.7	1.0	2.9
1999	11.2	5.5	3.2	2.3	1.4	3.8
2000	14.0	6.9	4.1	2.8	1.7	4.8
2001	16.7	8.3	4.9	3.4	2.0	5.8
2002	19.5	9.7	5.7	3.9	2.4	6.7
2003	22.3	11.0	6.5	4.5	2.7	7.7
2004	25.1	12.4	7.3	5.1	3.1	8.7
2005	27.9	13.8	8.1	5.6	3.4	9.6
2006	30.7	15.2	8.9	6.2	3.7	10.6
2007	33.5	16.5	9.7	6.8	4.1	11.5
2008	36.3	17.9	10.5	7.3	4.4	12.5
2009	38.7	20.5	11.0	8.2	5.2	21.6
2010	41.2	23.1	11.5	9.1	6.0	30.6
2011	43.6	25.7	11.9	10.0	6.8	39.7
2012	46.9	25.3	11.5	9.8	7.5	34.7
2013	50.2	25.0	11.2	9.6	8.2	29.7
2014	53.4	24.6	10.8	9.4	8.9	24.7
2015	54.5	28.4	14.0	11.3	11.6	39.6
2016	55.6	32.1	18.0	17.0	14.0	54.0

(a) *Source:* Grains Research and Development Corporation Survey Report 2016: agroecological zones percentages for 2008, 2011, 2014 and 2016 combined to state level by Agtrans; linear interpolation used to estimate years not surveyed.
(b) *Source:* Agtrans assumption of 0% CTF adoption in all states in 1995, after discussions with Dr Jeff Tullberg in 2019.

Table 10 Estimated area of wheat grown under CTF in northern New South Wales and southern Queensland, by year, 1995–2023

Year (ended 30 June)	Estimated southern Qld wheat area (ha)	Estimated CTF in Southern Qld (%)	Estimated area of CTF in southern Qld wheat area (ha)	Estimated northern NSW wheat area (ha)	Estimated CTF percentage in northern NSW (%)	Estimated area of CTF in northern NSW wheat area (ha)
1994–95	320,800	0.0	0	526,880	0.0	0
1995–96	501,600	2.8	14,045	861,360	1.4	12,059
1996–97	784,799	5.6	43,949	1,181,040	2.8	33,069
1997–98	799,200	8.4	67,133	1,086,320	4.1	44,539
1998–99	911,200	11.2	102,054	1,174,380	5.5	64,591
1999–2000	876,800	14.0	122,752	1,267,250	6.9	87,440
2000–01	708,000	16.7	118,236	1,358,270	8.3	112,736
2001–02	483,200	19.5	94,224	1,275,020	9.7	123,677
2002–03	411,200	22.3	91,698	1,108,150	11.0	121,897
2003–04	632,000	25.1	158,632	1,473,710	12.4	182,740
2004–05	568,800	27.9	158,695	1,574,720	13.8	217,311
2005–06	622,400	30.7	191,077	1,314,980	15.2	199,877
2006–07	510,400	33.5	170,984	1,330,520	16.5	219,536
2007–08	535,200	36.3	194,278	1,483,330	17.9	265,516
2008–09	816,000	38.7	315,792	1,599,140	20.5	327,824
2009–10	769,600	41.2	317,075	1,473,710	23.1	340,427
2010–11	724,800	43.6	316,013	1,411,550	25.7	362,768
2011–12	762,400	46.9	357,566	1,431,160	25.3	362,083
2012–13	692,800	50.2	347,786	1,290,190	25.0	322,548
2013–14	606,400	53.4	323,818	1,209,530	24.6	297,544
2014–15	507,200	54.5	276,424	1,171,420	28.4	332,683
2015–16	488,800	55.6	271,773	1,085,210	32.1	348,352
2016–17	487,600	55.6[a]	276,666	1,201,760	32.1[a]	385,765
2017–18	488,000	55.6[a]	271,328	1,147,000	32.1[a]	368,187
2019–2023	488,000[b]	55.6[a]	271,238	1,147,000	32.1[a]	368,187

(a) Estimated by Agtrans as equal to the last authoritative figure in 2016.
(b) Estimated by Agtrans as equal to the last authoritative figure in 2018.

7.2.5 Value of productivity gains in Australia

Adopting CTF for wheat production has resulted in increased wheat yields, as well as cost changes and improved environmental outcomes. Crops other than wheat have also benefited from the early ACIAR investments, although not included in the earlier Vere (2005) valuation of impacts, nor in this update.

The current valuation framework for the Australian component is different to that used by Vere; for example, data on the adoption of CTF are now available, and allowed adoption assumptions to be developed for the ACIAR projects' two target regions (northern New South Wales and southern Queensland).

But some of the assumptions made by Vere (2005) are still relevant to the current valuation framework used in the update; for example, the yield increase of 10% and bringing forward of the benefits by 3 years. Vere's assumption of the additional costs of using CTF of $4 per ha (2005 A$ terms) was also used in the update. The overall assumptions used by Vere on adoption, yield and cost changes were generally endorsed by discussions with Dr Jeff Tullberg in June 2019.

Table 11 provides a summary of assumptions associated with productivity and timing used in the current assessment.

7.2.6 Attribution

The majority of the impact from the adoption of CTF in northern New South Wales and southern Queensland to the present time could be attributed to the ACIAR project investments, including that of the University of Queensland and CAU, as presented in Table 2.

The 100% attribution assumed in this evaluation update assumes that some spill-in impacts from other Australian CTF initiatives to the two Australian regions would have been offset by equivalent spill-out impacts from the ACIAR investments to other Australian regions.

7.2.7 Counterfactual

Without the ACIAR investment, investment in CTF technology in northern New South Wales and southern Queensland is assumed to have been delayed. The assumption for the counterfactual is that without the ACIAR investment the delay in CTF technology would have been 3 years (Table 11).

Table 11 Assumptions for valuing CTF productivity gains in the target regions of Australia

Variable	Assumption	Source/rationale
Value of productivity and profitability impacts		
Estimated wheat yield across the two target regions before CTF	1.6 tonnes per ha	Average for each of Queensland and New South Wales wheat yields adjusted for years ending June 1989 to June 1995, and for estimated areas of wheat in each of the two target regions in the year ended June 1995 (ABARES Commodity Statistics, various years, and data in Table 10)
Increase wheat yield due to CTF	10%	Vere (2005)
Farm gate value of milling wheat 2018–19 terms	$300 per tonne less $20 per tonne delivery	ABARES (2019); delivery cost estimate made by Agtrans Research
Additional cost of using CTF	$5.80 per ha (2018–19 A$ terms)	Based on Vere (2005), Table 6, an assumption of $4 per ha expressed in 2005 A$ terms.
Timing of impact		
Start of adoption/benefits with ACIAR projects	1996	Based on first year of significant adoption of CTF in Australia, based on discussions with Dr Jeff Tullberg (2019)
Start of adoption/ benefits without ACIAR projects	1999	Lag of 3 years based on Vere (2005)

7.2.8 Impacts not valued

As for China, some Australian impacts emanating from the ACIAR projects were not valued in the updated impact assessment.

Environmental and natural resource management impacts

Some of the environmental and natural resource management impacts identified but not valued are similar to those identified in China. These included:

- reduced soil compaction and erosion
- reduced nutrient loss
- increased soil moisture
- reduced greenhouse gas emissions from increased crop yields.

Social impacts

Social impacts in Australia included spill-over impacts to the wheat supply chain and regional communities from increased wheat yields, and increased producer profitability.

The reasons for non-valuation of these environmental and social impacts included:

- the lack of and complexity of identifying the pathways to impact
- the difficulty in assigning credible values to the assumptions associated with each of the non-valued impacts identified
- the resources and time available for additional assessment.

Further, some of these non-valued impacts might have been included already, indirectly, in the impacts valued (for example, increased soil moisture retention leading to crop yield increases, with the increased value of the yield increase having an impact on parts of the supply chain, like additional transport and storage demand).

8 Results

The benefits estimated for cropping farmers in China were added to those for wheat producers in Australia. All past costs and benefits were expressed in 2018–19 A$ terms using the implicit price deflator for GDP[4] (ABS 2019). All benefits after 2018–19 were expressed in 2018–19 A$ terms.

All costs and benefits were discounted to 2019–20 (year of evaluation) using a discount rate of 5%. The base analysis used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for a period of 30 years after the first year of investment (1992–93), in line with the ACIAR Impact Assessment Guidelines (Davis et al. 2008).

The investment criteria are reported for the total investment and the ACIAR investment alone in Tables 12 and 13. The ACIAR present value of benefits (PVB) (Table 13) is estimated by multiplying the total PVB by the respective ACIAR proportion of total undiscounted costs expressed in 2018–19 A$ terms (almost 50%).

The internal rate of return is the discount rate that makes the net present value of all cash flows equal to zero. In the case of the current impact assessment, the present value of benefits exceeds the present value of costs from year zero (the first year of investment in the ACIAR CT/CTF projects), so no discount rate will make the net present value equal to zero.

Table 12 Investment criteria for total investment (discount rate 5%), by 5-year period

Investment criteria	Years from first year of investment					
	5	10	15	20	25	30
Present value of benefits ($m)	68.6	382.6	3,653.9	15,193.5	27,602.1	35,043.6
Present value of costs ($m)	12.5	16.0	16.0	16.0	16.0	16.0
Net present value ($m)	56.0	366.6	3,637.9	15,177.5	27,586.1	35,027.6
Benefit:cost ratio	5.5	23.9	228.3	949.5	1,725.0	2,190.0
Internal rate of return (%)	Not calculable					

Table 13 Investment criteria for ACIAR investment (discount rate 5%), by 5-year period

Investment criteria	Years from first year of investment					
	5	10	15	20	25	30
Present value of benefits ($m)	34.1	190.4	1,818.5	7,561.5	13,736.9	16,809.6
Present value of costs ($m)	4.9	8.0	8.0	8.0	8.0	8.0
Net present value ($m)	29.2	182.4	1,810.5	7,553.5	13,729.0	16,801.6
Benefit:cost ratio	7.0	23.9	228.2	948.8	1,723.6	2,109.1
Internal rate of return (%)	Not calculable					

4 The implicit price deflator for GDP is a price index for all final goods and services produced. It is calculated as the ratio of nominal GDP to real GDP. The GDP deflator expresses the extent of price level changes, or inflation, within an economy. The implicit price deflator for GDP is used to convert past, nominal dollar terms to current, real dollar terms in a cash flow analysis.

Figure 1 shows the annual cash flow of estimated undiscounted benefits for both China and Australia from 1993 to 2023. The graph shows that there was little change between 1993 and 2006, estimated benefits then grew to a peak of A$2,500 million in 2014, before declining to about A$1,500 million in 2023.

The highest annual undiscounted investment costs exceeded A$1 million in only 1 year (1997), so are not provided in Figure 1.

Table 14 shows the relative contribution to the total benefits estimated from each of the China and Australian cropping sectors. The results show the dominance of the estimated benefits from the cropping sector in China due to various factors, as follow:

- The research directly benefited two regional areas in Australia (target area of wheat of about 1.5 million ha), but some 12–16 million ha of wheat in China.
- The research in China focused on CT. In Australia, CT was already being adopted, and the Australian research component of the project focused on CTF, largely a further refinement of CT.
- A large proportion of the benefits to China were contributed by CT used in maize production in addition to wheat, whereas the Australian CTF contribution was estimated only for wheat.
- While crop yield increases in both countries were valued, a significant cost saving per ha also was valued in China.

While the benefits were dominated by the impacts for China, the benefits to Australia on their own are significant (currently a PVB of $160.9 million), and would have given a benefit:cost ratio of 10.05:1 for the total investment, even if China had not adopted CT.

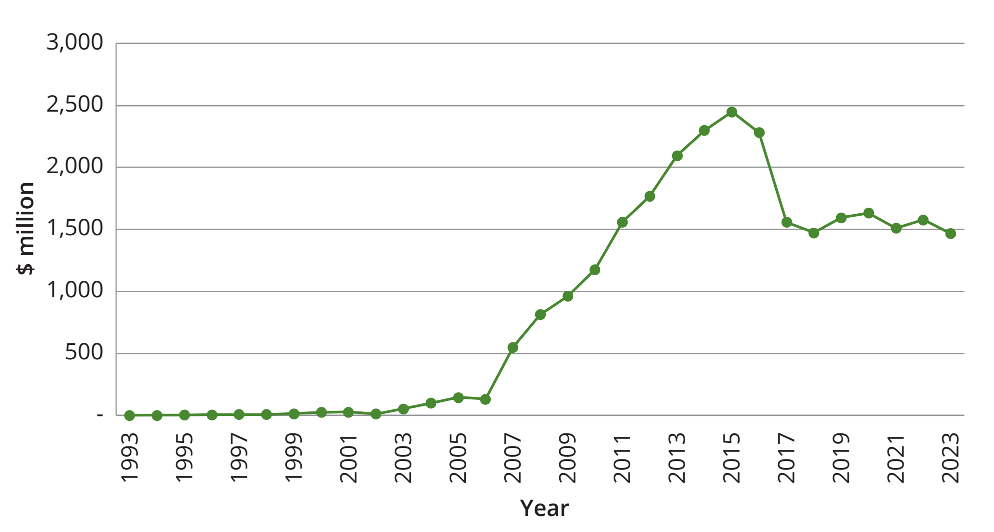

Figure 1 Annual cash flow of undiscounted benefits, by year, 1993–2023

Table 14 Contribution of CT and CTF cropping areas in China and Australia to total estimated benefits

Impact	Contribution to PVB ($m)	Contribution to PVB (%)
China component	34,882.66	99.5%
Australia component	160.89	0.5%
Total	**35,043.56**	**100.0%**

8.1 Sensitivity analyses

Sensitivity analyses were undertaken for various variables used in the valuation that were considered key drivers of the investment criteria or were uncertain. Tables 15–20 show the results of the sensitivity analyses.

A sensitivity analysis on the discount rate was completed. Table 15 shows the results.

Table 16 presents the sensitivity of the investment criteria to the assumed yield increase for China and Australia. The sensitivity of the investment criteria is reasonably low. This low sensitivity was driven by two key factors:

- the use of CT delivered other, non-yield related benefits (for example, lowered production costs per mu)
- a key driver of the estimated expected benefits was the increased area of CT in China—the increased area of CT may not have been sensitive to the yield range tested in the current sensitivity analysis.

A sensitivity analysis on the assumption of the maximum level of adoption of CT in China was completed. Table 17 presents the results, which showed a moderate sensitivity to the maximum level of CT adoption assumed.

Table 15 Sensitivity to discount rate (total investment, 30 years)

	Discount rate		
Criterion	**0%**	**Base (5%)**	**10%**
Present value of benefits ($m)	27,287.8	35,043.6	46,675.0
Present value of costs ($m)	5.2	16.0	47.3
Net present value ($m)	27,282.6	35,027.6	46,627.6
Benefit:cost ratio	5,268.1	2,190.0	985.9

Table 16 Sensitivity to the assumed yield increase (total investment, 5% discount rate, 30 years)

	Yield increase		
Criterion	**75% base**	**Base in each country and for each crop[(a)]**	**125% base**
Present value of benefits ($m)	32,176.2	35,043.6	37,910.9
Present value of costs ($m)	16.0	16.0	16.0
Net present value ($m)	32,160.2	35,027.6	37,894.9
Benefit:cost ratio	2,010.8	2,190.0	2,369.2

(a) Base yield increases provided in Table 6 for China (wheat and maize) and Table 11 for Australia (wheat).

Table 17 Sensitivity to the assumed maximum level of CT adoption in China (total investment, 5% discount rate, 30 years)

	Maximum adoption of CT		
Criterion	**25%**	**40% across both crops (wheat and maize) base[(a)]**	**60%**
Present value of benefits ($m)	31,278.9	35,043.6	40,063.1
Present value of costs ($m)	16.0	16.0	16.0
Net present value ($m)	31,262.9	35,027.6	40,047.1
Benefit:cost ratio	1,954.7	2,190.0	2,503.7

(a) Table 6 presents base assumptions for the maximum level of CT adoption in China (wheat and maize).

The base assumption of total production cost savings of 63 RMB/mu includes savings in labour, fuel, water and fertiliser. The available data did not allow the various components of the total savings to be broken down.

As a result, including labour savings creates some difficulty in the analysis, as the significance of any labour savings between 1992–93 and present day might have changed. For example, current rural labour shortages in China are likely to have increased the importance of labour-saving agricultural practices in recent years. As the specific value of labour savings could not be excluded from the analysis, a sensitivity analysis was conducted on the RMB/mu saving assumed from adoption of CT in China. Table 18 presents the results, which showed a moderate to high sensitivity to the assumed cost saving for CT in China, indicating that the efficiency gains from adoption of CT are a key driver of the investment criteria.

A further sensitivity analysis was conducted on the counterfactual time lag assumed for the adoption of CT in China. Table 19 presents the results. The counterfactual is a key driver of the high, positive results in the updated impact assessment, and the results show that, even using the same 3-year lag from the 2005 assessment, the benefits from the ACIAR investment are very positive.

Finally, a sensitivity analysis was conducted on the prices assumed for wheat and maize in China, and wheat in Australia. Table 20 shows the results. Price is a key determinant of the magnitude of expected benefits, and is likely to have changed over time since the original investment in the two ACIAR projects. Further, future potential price also will affect the value of benefits from CT/CTF in both China and Australia in the future.

8.2 Scenario analysis

Based on the variables examined in the sensitivity analyses, an additional analysis was carried out for three overarching scenarios. These were:

- a pessimistic scenario, where all relevant assumptions were set to the minimum values assumed in the sensitivity analyses
- a base case scenario (assumptions as per Tables 6 and 11)
- an optimistic scenario, where relevant assumptions were set to their maximum potential values.

This analysis shows the potential range of investment criteria for the ACIAR investments. Table 21 presents the results.

The scenario analysis showed that, even with all key assumptions set to their minimum estimated values (10% discount rate, 75% of base yield gain from CT/CTF, 25% maximum adoption of CT in China, 30 RMB/mu cost saving for growers adopting CT in China, 70% of base crop prices, and only a 3-year time period lag for the counterfactual for China), the investment criteria are highly positive.

This finding should provide confidence to ACIAR and its funding partners that the original investment in the two ACIAR projects has produced a positive return on investment.

Table 18 Sensitivity to the assumed RMB/mu saving from adoption of CT in China (total investment, 5% discount rate, 30 years)

	RMB/mu savings from CT		
Criterion	30 RMB/mu	63 RMB/mu base[a]	90 RMB/mu
Present value of benefits ($m)	22,557.8	35,043.6	45,259.2
Present value of costs ($m)	16.0	16.0	16.0
Net present value ($m)	22,541.8	35,027.6	45,243.2
Benefit:cost ratio	1,409.7	2,190.0	2,828.4

(a) Table 6 presents base assumptions for the RMB/mu savings from CT adoption in China (wheat and maize).

Table 19 Sensitivity to the assumed time lag for adoption of CT in China (total investment, 5% discount rate, 30 years)

Criterion	Time lag assumed		
	3 years	5 years	10 years base[(a)]
Present value of benefits ($m)	14,084.0	21,176.6	35,043.6
Present value of costs ($m)	16.0	16.0	16.0
Net present value ($m)	14,068.0	21,160.6	35,027.6
Benefit:cost ratio	880.2	1,323.4	2,190.0

(a) The counterfactual for the valuation of impacts for China is defined and described in Sections 3.3.1 and 7.1.7.

Table 20 Sensitivity to the assumed prices for wheat and maize in China and wheat in Australia (total Investment, 5% discount rate, 30 years)

Criterion	Crop prices		
	70% of base	Base[(a)] China—Wheat 1,900 RMB/t Maize 1,600 RMB/t Australia—Wheat A$280/t	120% of base
Present value of benefits ($m)	31,602.7	35,043.6	37,337.5
Present value of costs ($m)	16.0	16.0	16.0
Net present value ($m)	31,586.7	35,027.6	37,321.5
Benefit:cost ratio	1,975.0	2,190.0	2,333.4

(a) Base assumptions for crop prices are reported in Table 6 (wheat and maize) for China and Table 11 (wheat) for Australia.

Table 21 Pessimistic, base and optimistic scenario analysis (total investment, 5% discount rate, 30 years)

Criterion	Scenario		
	Pessimistic[(a)]	Base[(b)]	Optimistic[(a)]
Present value of benefits ($m)	8,545.3	35,043.6	47,535.1
Present value of costs ($m)	47.3	16.0	5.2
Net present value ($m)	8,497.9	35,027.6	47,529.9
Benefit:cost ratio	180.5	2,190.0	9,177.0

(a) Pessimistic and optimistic assumptions are taken from Tables 15–20.
(b) Base assumptions are provided in Table 6 for China (wheat and maize) and Table 11 for Australia (wheat).

8.3 Comparison of results: 2005 and 2019

Some of the assumptions underpinning the updated assessment for the Australian component were similar to the original assessment in 2005. The similar assumptions included the yield increase, the change in costs per ha, and the 3-year advancement of benefits due to the ACIAR investment. These assumptions were validated through consultation with Dr Jeff Tullberg.

But data were now available for wheat areas by state up to 2018, and for adoption of CTF by state up to 2016. This enabled better informed and higher estimates to be made by year on the adoption of wheat area under CTF in the target regions, compared with those estimates in the original assessment.

The other major difference was the use of a producer surplus approach in the updated assessment compared with a total economic surplus approach in the original assessment.

The major difference in the assumptions for valuing the China impacts were a 10-year advancement of benefits compared with only 3 years in the original assessment.

Also, time series data on actual wheat and maize crop areas in the target regions were available as well as statistics on the actual adoption of CT. These data were used to better estimate the area by year of adoption of CT for each of the two crops.

Due to various agricultural policy changes in China, the area and production of wheat and maize was significantly higher than the 3-year time lag assumption used in the 2005 assessment. This resulted in the area of CT for both crops being higher than that assumed in the original assessment.

The updated assessment is characterised by a significant improvement in the estimated investment criteria, particularly due to the revised data and assumptions made in the update for the China component.

Table 22 shows a comparison of the assumptions used in the 2005 assessment compared with the current 2019 assessment.

Table 22 Summary of key assumptions, comparison between the 2005 assessment and the 2019 updated assessment

	2005 assessment[a]		2019 assessment[b]	
Assumption/variable	**China**	**Australia**	**China**	**Australia**
Yield increase (%)				
Wheat	17.7	10.0	7.5	10.0
Maize	12.3	n/a	5.8	n/a
Cost saving (A$/ha)				
Wheat	26.6	–4.0		–5.8
Maize	93.6	n/a	189.0[c]	n/a
Adoption ceiling 'with' investment (%)				
Wheat	10.0	37.0		55.6 (southern Qld) 32.1 (northern NSW)
Maize	10.0	n/a	40.0[d]	n/a
Adoption ceiling 'without' investment (%)				
Wheat	8.0	135.2		55.6 (southern Qld) 32.1 (northern NSW)
Maize	8.0	n/a	40.0	n/a

Note: the crop prices used in the 2005 impact assessment were not reported, so could not be compared in the updated assessment.
(a) Estimates assumed to be in 2004–05 A$ terms where applicable.
(b) Estimates reported in 2018–19 A$ terms.
(c) Based on data obtained during the field trip, where the average cost saving of the adoption of CT (all crop types) against conventional tillage farming was 63 RMB/mu made up of labour, fuel, water and fertiliser savings. See Table 6 for further details.
(d) Maximum proportion of combined wheat and maize cropping area in northern China grown using CT by 2023.

9 Discussion and conclusion

This report updates a 2005 impact assessment of the investment in two ACIAR projects associated with conservation tillage projects in China and controlled traffic farming in Australia (1992–2003).

The 2005 assessment, by David Vere, was undertaken in an ex-ante benefit–cost context, where the projects' costs were known, and the benefits were projected estimates of the expected project returns. The assessment demonstrated positive economic benefits, as well as environmental and social benefits, to both China and Australia.

The ACIAR projects enabled the use of CT to be established in China with significant benefits to the cropping sector. The projects enabled an increase in farm mechanisation and machinery manufacture, and contributed to the building of research capacity for CT in China.

Currently, several CT machinery manufacturers are exporting CT technology to other developing countries, and some Chinese firms are adapting machinery for the conditions in these other countries. So, the expansion of CT capacity has enabled China to be an exporter of knowledge, and a leader in the development of such technologies in other countries.

The two ACIAR project investments were the catalyst for the development and adoption of CT in China. Consultation with government officials in China indicated that the success of the ACIAR projects, in terms of promoting CT adoption, was achieved through the commitment of ACIAR and its funding partners to the long-term project investment. This enabled researchers to demonstrate the benefits of CT to industry and government, and start the work required to develop specific machinery to support CT adoption for Chinese agricultural conditions.

Discussions held with CT researchers, government representatives and industry personnel during the field trip made it clear that without the ACIAR projects—which demonstrated that CT was practical and could deliver long-term benefits in China—the additional government support of research and extension would not have been forthcoming as early as it was.

Further one of the reasons CSAM is based in Beijing is because of the success and adoption of CT in China, with appropriate expertise/ capacity and capability readily available.

The field trip to China exposed significant goodwill towards Australia, due to the initial investment in CT from ACIAR. Third country CT development may be an opportunity for further collaboration between Australia and China, as personnel in China were welcoming of the idea of trilateral collaborations.

Also, apart from CT usage in the north of China as valued in the current assessment, there has been further CT development in other regions outside of the original 13 provinces in China. For example, there has been some development of CT in southern China, and potentially for crops other than wheat and maize (for example, rice), extending the benefits of CT further than originally anticipated.

In Australia, the importance of the ACIAR investment to developing CTF in northern New South Wales and southern Queensland was highlighted with discussions with Dr Jeff Tullberg in 2019. Dr Tullberg was a joint Project Leader and Principal Researcher with Professor Gao Huanwen for both the Australia and China components of the ACIAR investments.

The current assessment estimated that, for the base case analysis, the ACIAR project investments generated:

- a net present value of $35,043.6 million (2018–19 A$ terms)
- a benefit:cost ratio of about 2,190.0:1.

The investment criteria estimated were significantly higher than the results reported in the original 2005 assessment, where the investments were estimated to have generated:

- a total economic surplus of A$2,640.1 million (2004–05 A$ terms)
- a net present value of A$578.4 million
- a benefit:cost ratio of 36.3:1.

A further pessimistic/optimistic scenario analysis indicated that the present value of expected benefits attributable to the ACIAR project investments was between $8,545.3 million and $47,535.1 million (2018–19 A$ terms), yielding:

- a net present value between $8,497.9 million and $47,529.9 million
- a benefit:cost ratio between 180.5:1 and 9,177.0:1.

The scenario analysis showed that, even with all key assumptions set to their minimum estimated values (10% discount rate, 75% of base yield gain from CT/CTF, 25% maximum adoption of CT in China, 30 RMB/mu cost saving for growers adopting CT in China, 70% of base crop prices, and only a 3-year time period lag for the counterfactual for China), the investment criteria are highly positive.

The benefits estimated that the China component contributed more than 99% of the total benefits estimated (in present value terms). The reasons for this were that:

- the research directly benefited only two regions in Australia (target area of wheat of about 1.5 million ha), but targeted some 12–16 million ha of wheat in China
- a large proportion of the benefits to China were contributed by CT used in maize production (in addition to wheat), whereas the Australian CTF contribution was estimated only for wheat
- the research in China focused on CT, but in Australia, it focused on CTF, a further refinement of CT, which was already being adopted in Australia
- while crop yield increases in both countries were valued, a significant cost saving per hectare from use of CT was also valued in the China component.

The 2019 update of IAS 33 faced some challenges, given the long period since the original assessment was completed. For example, China has undergone a period of significant change and economic development over the past few decades. Government policy has played a key role in agricultural production, and prices and government interest and support continue to be significant factors influencing the development of agriculture in China.

Prices of agricultural inputs and outputs have changed over time. Applying 2019–20 prices to the impacts of an investment made in 1993, although necessary for the current analysis, might not account for complicating factors like the changing ratio of prices for inputs and outputs over time in both China and Australia.

While some increase in investment criteria could be attributed to differences in the assessment methods and assumptions (for example, no negative impact for non-adopting producers), both methods used a similar approach of bringing forward the benefits from CT in China and CTF in Australia. In other words, the same benefits attributable to CT and CTF would have occurred anyway, but would have started later.

Key drivers of the higher investment criteria in the updated assessment included:

- much higher adoption of CT/CTF in both China and Australia than predicted by Vere for both countries—in China, CT adoption was four times higher than assumed in the 2005 assessment, while in Australia adoption of CTF was three to five times higher
- higher cost saving per hectare for adoption of CT in China—data from the 2019 field trip indicated an average cost saving of about $189/ha for CT (versus conventional tillage) in China
- higher wheat and maize crop areas and production in China—Vere (2005) estimated total, average annual crop production of 133,122,000 tonnes of wheat and maize (combined) in China, but actual production from 2005 was higher than predicted, due to various changes to policy and other developments in China, with a total production of 143,968,780 tonnes in 2018
- a higher lag than anticipated—though the benefits in Australia were driven by a 3-year lag similar to what was assumed in the 2005 assessment, the benefits in China (99% of the PVB) were driven by a 10-year lag (3 years in the original assessment) (the increased lag for China was strongly supported by information obtained through consultation during the 2019 China field trip)
- higher prices for wheat in Australia, and wheat and maize in China than those estimated in 2005. The China Central Government also implemented policies that affected crop prices, but it is unclear what impact these had on the 2005 impact assessment. More recently, China has undertaken a campaign to bring domestic prices more in line with international market prices, by reducing policy support, which served as a floor for prices of standard wheat (USDA 2019b). Applying 2019–20 prices to the impacts of an investment made in 1993, although necessary for the current analysis, might not take into account complicating factors such as the changing ratio of prices for inputs and outputs over time in both China and Australia.

Overall, the findings of the updated 2019 assessment of IAS 33 indicate highly favourable outcomes for the original ACIAR project investment.

Consultation with key stakeholder's in China also revealed a very positive attitude by Chinese authorities and individuals towards the initial investment in CT by ACIAR, the impact it has had on China's cropping sector, and the capacity built for CT research and development and machinery manufacture in China.

These findings should provide confidence to ACIAR and its funding partners that the original investment in the two ACIAR projects has produced a significant and positive return on investment.

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Appendix 1: Summary of the field trip to China

Purpose of the field trip

The scoping study identified that a field trip to China was needed to update assumptions and gather further information for an updated impact assessment on ACIAR's CT investment in China and Australia.

Consultation with numerous stakeholders was required to better understand how ACIAR's investment in CT has affected CT in China since the end of the ACIAR projects.

Due to the number of stakeholders and associated language barriers, a field trip was necessary to identify the relevant outcomes and impacts of the ACIAR investment.

Dates and schedule

Table A1 Program for Agtrans visit to China, 1–12 July 2019

Day	Date	Activity
–	1 July	Arrive in Beijing
1	2 July	Meetings at the Ministry of Agriculture and Rural Affairs
2	3 July	China Agricultural Machinery Testing Centre
3	4 July	Meetings at the Asia Pacific Farm Machinery Centre and Conservation Tillage Research Centre at China Agricultural University (CAU) Meeting at UN Economic and Social commission for the Asia-Pacific, Centre for Sustainable Agriculture Mechanization (CSAM)
4	5 July	Travel Beijing–Shijiazhuang Travel Shijiazhuang–Xinji Visit Nonghaha farming machinery factory, production of conservation tillage machinery for two-crop areas in Northern China
5	6 July	Travel Xinji–Shijiazhuang Travel Shijiazhuang–Beijing
6	7 July	Rest day
7	8 July	Travel Beijing–Qingdao Observe the no-tillage planting of wheat on both sides along the way
8	9 July	Visit cooperative with conservation tillage Fly to Jiamusi from Qingdao
9	10 July	Debont Dawei Jiamusi Branch, manufacturer of conservation tillage machinery suitable for corn
10	11 July	International Seminar on China Conservation Tillage
–	12 July	Depart Beijing for Australia

Trip summary

Day 1 (2 July 2019)

Locations visited

Beijing

People met

Wang Guozhan, Ministry of Agriculture (MoA)

Overview

Meeting was to obtain a brief overview of:

- conservation tillage (CT) in China by the MoA
- the history of CT
- where CT research, extension, and adoption is now
- where CT research, extension, and adoption is expected to advance in the future.

The meeting outlined the importance of the ACIAR initial investment, and that the MoA recognised that the ACIAR investment kickstarted CT adoption in China. For further MoA investment in CT, there needed to be a long-term commitment to a CT project. The ACIAR projects provided the initial long-term investment needed.

Further initial information was sought. The MoA official provided initial estimates of investment that had been made and other associated information.

Knowledge gained

The meeting confirmed that the results of ACIAR investment was one of, if not, the most important factors, in the decision by the MoA to fund further CT research and extension in China. It was reiterated also that there had been significant additional investment by the MoA in CT since the end of the ACIAR projects, some of which was not captured by Vere (2005) in the initial ACIAR assessment.

Day 2 (3 July 2019)

Locations visited

China Agricultural Machinery Testing Centre

People met

Zhang Yuan, Liu Bo, Qu Guibao, Feng Jian

Overview

The second day meeting was at China Agricultural Machinery Testing Centre. There were four presentations on CT in China, covering extension technology, equipment selection, CT standards, CT seeders, and adoption of CT.

The planning mechanisms and role of government (both local and national) associated with CT were explained.

The presentations allowed greater understanding of the size and scale of CT adoption, the challenges overcome in securing adoption, the success of the ACIAR projects and the benefits of CT to the farmers.

There was a discussion on Chinese seeders compared with Western seeders. While Chinese seeders need further development, it was noted that Chinese seeders were built for Chinese conditions, and farms and at an appropriate price point for Chinese farmers.

Day 3 (4 July 2019)

Locations visited

Centre for Sustainable Agricultural Mechanization and Asia Pacific Farm Machinery Centre and Conservation Tillage Research Centre at China Agricultural University

People met

Marco Silvestri and Yuee Feng, He Jin

Overview

The meeting with CSAM brought to light the CT work China is doing in the Asia-Pacific region. Through the capacity China has since developed in the CT space, knowledge has been able to be extended to other countries.

It was highlighted that the CAU work with CSAM is important, and without CAU and China's involvement, it would be likely that CSAM would not exist in its current form (Macro Silvestri pers. comm. 2019). CAU has enabled CSAM to undertake work in China due to the increase in capacity and personnel in China.

As China now has the capacity in CT, researchers and manufacturers from China have been instrumental in aiding development of CT in the Asia-Pacific region. This meeting brought to light the extension work of Li Hongwen in various regions. For example, Li Hongwen has conducted training courses in CT in Cambodia.

Through the work of CAU, the previous strict definition of CT has also widened, with CT now being viewed in a more pragmatic sense than the previous strict no-till definition.

Chinese-made technology is now being used in countries such as Cambodia and Sri Lanka, with seeders, planters and machinery being used.

Day 4 (5 July 2019)

Locations visited

Xinji, Hebei

Firm met

Hebei Nonghaha Agricultural Machinery Group Co. Ltd (Nonghaha) Headquarters

People met

- Wu Yuntao, General Manager
- Liu Congbin, Vice General Manager
- Zhang Yongshen, General Engineer
- Gu Bangkai, Production Manager
- Xiao Shengyuan, Technology Manager
- Ji Liqiang, Technology Manager
- Cao Xiaodan, Manager for Department of Foreign Trade
- Du Zheng, Technician
- Cui Guanghui, Technician.

Overview

Visited CT farm in Xinji, Hebei. During initial discussions it was discovered that Nonghaha was still investing and developing seeder technology, as there are issues with maize-to-wheat rotations, with maize straw blocking the seeders. From visual inspection, there was evidence that CT is providing beneficial soil and environmental impacts, as illustrated by comparisons of a CT field and a non-CT field.

Following the farm site visit, the evaluation team was taken to Nonghaha's factory and headquarters for a tour and information session. During the tour, there was a visit to the production line of CT parts. Nonghaha employs locals within the area to build CT components and graduates to develop new machinery. The firm employs about 400 people.

Nonghaha noted that there are subsidies for CT machinery development, but only if there is a potential for upgrading production capacity and technological innovation. Nonghaha personnel noted that CAU and MoA support of CT has enabled farmer acceptance of CT technology. Without this support, Nonghaha would not be viable.

For adoption, Nonghaha provides demonstrations to farmers, allowing farmers to see CT seeders in action in the field. These extension days can attract up to 400 people. There are also small-sized demonstrations run by Nonghaha, with these demonstrations having occurred in 19 provinces across China.

Day 5 (6 July 2019)

Travel day

Day 6 (7 July 2019)

Rest day

Day 7 (8 July 2019)

Travel day—observation of no-tillage wheat along the way.

Day 8 (9 July 2019)

Locations visited

Laixi, visited farms Debont Daweo Jiamusi

People met

Ge Tongyan

Overview

Undertook a brief field trip to see further farms to observe CT machinery in action. On a trial field day, many farmers came to watch the demonstration, and it was evident that farmers were interested particularly in the demonstration of seeders. At the demonstration site there was a comparison field where conventional tillage was practiced. Visual evidence showed a clear difference in yield and in soil retention between CT and conventional tillage methods.

Day 9 (10 July 2019)

Locations visited

Jiamusi

People and firms met

Vice Mayor/Mayor of Jiamusi and Debont Daweo

Overview

Visited Debont factory including an inspection of the production facilities. It was reiterated that CAU involvement in CT has allowed greater adoption of CT, enabling opportunities for the private sector to provide seeders. Debont are also exporting machines to Africa, as Chinese machines are more suitable than Western machines for African conditions. The aim of Debont is to increase CT usage in Heilongjiang from 20 million mu in 2019 to 40 million mu in 2020.

During the visit to the Vice-Mayor's office, it was outlined how CT provides an opportunity for farmers to increase yield and income, and to benefit society in general through improved environmental outcomes. In Jiamusi, farmers are not allowed to burn straw, so CT has made compliance with this law easier on farmers. Also, as Jiamusi is predominantly dryland farming, CT has improved moisture retention.

Day 10 (11 July 2019)

Locations visited

International Seminar on China Conservation Tillage

People met

Li Hongwen

Overview

The final day of the trip was the International Seminar on China Conservation Tillage organised by CAU. The seminar was also to launch the new 'China Institute for Conservation Tillage'.

Advice from Li Hongwen was sought, and much data from previous consultations with other stakeholders were confirmed. In addition to the information confirmed, Li Hongwen also provided an estimate on the counterfactual scenario relevant to the earlier ACIAR investment.

He indicated that a then benefits of the ACIAR projects would have been delayed by 5–10 years if the ACIAR projects had not been funded. As there were external events around 2001, with major dust storms in Beijing, it would have been likely CT research in China would have been initiated around the year 2000.

Summary of data and information collected, and presentations given

Much data were collected from numerous sources during the field trip. Some of the data were already available from the scoping study, but their importance was further confirmed from discussions, which presented the opportunity to expand understanding and relevance. Additional qualitative information was collected from the field trip.

This section presents a full list of all data and resources assembled from the field trip.

Papers

- Li H., Gao H., Wu H., Li W., Wang X. and He J. 2007. Effects of 15 years of conservation tillage on soil structure and productivity of wheat cultivation in northern China. Soil Research 45(5), 344–350.
- Jin H., Hongwen L., Xiaoyan W., McHugh A.D., Wenying L., Huanwen G. and Kuhn, N.J. 2007. The adoption of annual subsoiling as conservation tillage in dryland maize and wheat cultivation in northern China. Soil and Tillage Research 94(2), 493–502.
- Jin H., Hongwen L., Kuhn N.J., Xuemin Z. and Wenying L., 2007. Soil loosening on permanent raised beds in arid northwest China. Soil and tillage research 97(2), 172–183.
- He J., Li H., McHugh A. D., Ma Z., Cao X., Wang Q., and Zhang X. 2008. Spring wheat performance and water use efficiency on permanent raised beds in arid northwest China. Soil Research 46(8), 659–666.
- Chen H., Bai Y., Wang Q., Chen F., Li H., Tullberg J.N., Murray J.R., Gao H. and Gong Y. 2008. Traffic and tillage effects on wheat production on the Loess Plateau of China: 1—crop yield and SOM. Soil Research 46(8), 645–651.
- Wang X., Gao H., Tullberg J.N., Li H., Kuhn N., McHugh A.D. and Li Y. 2008. Traffic and tillage effects on runoff and soil loss on the Loess Plateau of northern China. Soil Research, 46(8), 667–675.
- Bai Y., Chen F., Li H., Chen H., He J., Wang Q., Tullberg J.N. and Gong Y. 2008. Traffic and tillage effects on wheat production on the Loess Plateau of China: 2—soil physical properties. Soil Research, 46(8), 652–658.
- Zhang X., Li H., He J., Wang Q., and Golabi M. H. 2009. Influence of conservation tillage practices on soil properties and crop yields for maize and wheat cultivation in Beijing, China. Soil Research 47(4), 362–371.

- He J., Li H., Rasaily R.G., Wang Q., Cai G., Su Y., Qiao X. and Liu L. 2011. Soil properties and crop yields after 11 years of no tillage farming in wheat-maize cropping system in North China Plain. Soil and Tillage Research 113(1), 48–54.
- He J., McHugh A.D., Li H.W., Wang Q.J., Li W.Y., Rasaily R.G. and Li H. 2012. Permanent raised beds improved soil structure and yield of spring wheat in arid north-western China. Soil Use and Management 28(4), 536–543.
- Hui L., Jin H., Qingjie W., Hongwen L., Sivelli A., Caiyun L., Zhanyuan L., Zhiqi Z. and Xiangcai Z. 2013. Effects of permanent raised beds on soil chemical properties in a wheat-maize cropping system. Soil Science 178(1), 46–53.
- Wang Q., Lu C., Li H., He J., Sarker K.K., Rasaily R.G., Liang Z., Qiao X., Li H. and Mchugh A.D.J. 2014. The effects of no-tillage with subsoiling on soil properties and maize yield: 12-year experiment on alkaline soils of northeast China. Soil and Tillage Research 137, pp.43–49.
- Li H., Wang Q.J., He J., Li H.W., Lu Z.Y., Rasaily R.G., Lu C.Y., Zhang X.C. and Zheng Z.Q. 2014. Permanent raised beds improved soil physical properties in an annual double-cropping system. Agronomy Journal 106(1), 7–14.
- Li H., He J., Gao H., Chen Y., and Zhang Z. 2015. The effect of conservation tillage on crop yield in China. Frontiers of Agricultural Science and Engineering 2(2), 179–185.
- Li H., He J., Bharucha Z. P., Lal R., and Pretty J. 2016. Improving China's food and environmental security with conservation agriculture. International Journal of Agricultural Sustainability 14(4), 377–391.

Data

Several sources of data were relevant to an updated impact assessment. Some the data sourced before and during the field trip were:

- 2003, 2005–17 National Agricultural Mechanisation Statistics
- CT area (hectares) in China, 1992–2012
- wheat and maize production in northern provinces, in regions and nationally
- wheat and maize areas in northern provinces, in regions and nationally
- number of no-till planter units, 2003–17
- CT area, 2008–17

Contacts during the field trip mentioned additional costs, benefits, and investment in CT in China, as follows:

Wang Guozhan, MoA:

- MoA has been spending 30 million RMB per year for CT extension in China.
- In 2002–13, the China Central Government and local government provided funding for CT investment, with 100 million RMB annually from 2009 to 2012 (local), with the China Central Government providing a total of 1.5 billion RMB (300 million RMB annually) for purchase of machinery from 2009 to 2013.
- Before 2002, local government did not provide much funding, and the investment from the China Central Government remained stable.
- After 2013 this stopped, and while they planned to provide 1.8 billion RMB in 2009–15, the China Central Government only invested 1.2 billion RMB.
- From 2018, a total of 2 billion RMB annually has been spent on improved farming methods in the north-eastern part of China. Three elements—subsoil amelioration, retaining straw, and protection of black soil—directly related to CT. CT was part of these measures.
- Efficiency gains were evident. For example, if CT was adopted on 1 mu of land, it would save 50 RMB for that mu. Without CT, one person can manage 5 ha, while with CT, one person can manage 50 ha.

China Agricultural Machinery Testing Centre:

- In 2002, CT was employed on 800,000 mu, but this expanded to 117 million mu in 2017. In 2017, 701 million mu of land retained straw on the field.
- Per 1 mu of land, CT can increase yield by 5%–15%, and gain 63 RMB per mu by saving:
  - three to five people in labour saving
  - about 3.2 L of diesel
  - 36–65 m^3 of water
  - 10% chemical fertiliser.
- The capital cost of machinery to a farmer increased from 2,000 RMB up to 10,000 RMB or more, with machinery life of up to 10 years.
- Compared to western machines, Chinese machines are relatively cheaper and more suitable to Chinese conditions, but might be of lower quality.

He Jin, CAU:

- In 2002–19, the MoA has provided 30 million RMB per year per CT adoption.
- There are different regional areas for CT cropping and cropping type—for example the northern region and north-west region has one crop, while the southern north-eastern region produces two crops.
- While there are no hard data on crop type per area, in general, the northern north-eastern region of China has one crop either maize, rice or potato.
- For two crops in the North China Plain, CT could be used on 2.9 billion mu, but it is used on only 42 million mu. So, there is significant scope for expanded use of CT.
- In the north (central) region—which grows wheat, maize and potato—CT could be used on 500 million mu, but it is used on only 10 million mu.
- In north-west China, CT could be used on 65 million mu, but it is used on only 9.6 million mu.
- Not counting land being used for potato, vegetables, and cotton, about 600 million mu of land in China is suitable for CT.

Nonghaha:

- Maize seeders are the main product of Nonghaha, accounting for 70% of factory production.
- In the Xinji, Hebei, area, no-till accounts for 95% of maize crops.
- In 2000, Nonghaha and CAU collaborated to design new machinery.
- In north-east China, there is a 95% CT adoption rate for maize, but only 50% adoption rate for wheat. Two crop areas in northern China (Yellow River, North China Plain) are suitable for CT use.
- Farmers can receive an operational subsidy of 10–30 RMB per mu.

Debont:

- The cost of a two-row CT seeder is 50,000 RMB without subsidies.
- For the farmer, the cost of a CT seeder is 25,000 RMB with subsidies.

Li Hongwen, CAU:

- In 2009, the China Central Government provided 3.6 billion RMB for CT extension and research.
- In 2002, the China Central Government started a national CT project, and invested 30 million RMB to continue work from CAU and the ACIAR project.
- There is a target of 60% CT adoption in north-east China by 2022, so the use of CT is expected to expand further.

Presentations

Talia Hardaker and Joseph Abell gave three presentations at the International Seminar on China Conservation Tillage in Beijing and to representatives in Jiamusi.

Talia Hardaker

Jiamusi: Conservation Tillage in Australia

Beijing: Conservation Tillage in Australia

Joseph Abell

Beijing: ACIAR's impact assessment

Overall impressions and summary

The field trip was successful in assembling information and data to help update ACIAR CT investment impact assessment. In addition, the field trip provided greater understanding of the impact of the ACIAR investment, and how the investments helped convince important stakeholders in China that CT was a suitable cropping method.

Before the field trip, Agtrans personnel held some knowledge of the potential impacts assembled through the scoping study, and had had some preliminary telephone contact with key stakeholders. But further investigation was needed to confirm information gaps, enhance understanding, follow up existing data, and discover the ongoing legacy of the ACIAR investment.

The field trip enabled Agtrans personnel to visit various stakeholders, including government officials, scientists, researchers and manufacturers, to find out why and how they are using CT, and how the ACIAR investment helped CT uptake.

Compared with the outcomes and impacts presented in Vere 2005, a significant update of the outcomes and impacts were able to take place due to the information gathered during the field trip.

For example, in consultations with stakeholders, it was emphasised that the investment by ACIAR in the 1990s demonstrated to the MoA that CT could be viable for farmers. This demonstration gave confidence to the MoA to invest in CT extension and development. The additional information gathered during the field trip has strengthened the assumption that the ACIAR project had a lasting impact on CT adoption in China. All stakeholders—from government officials to machinery companies—have mentioned the importance of the ACIAR project in improving confidence in CT technology in China.

An important set of information that was gained from the field trip was the extension costs by the national and providential governments. Vere's impact assessment only considered extension that was planned in 2006 or had already been funded. The field trip revealed the further funding that was forthcoming after the initial Vere analysis, which could not be captured in the scoping study.

The information gaps identified in the scoping study were also filled during the field trip. Before the field trip, the scoping study identified that CT has been adopted in China, but the adoption rates and impacts for farmers and policy-makers in China was insufficient and/or lacked confidence.

With feedback and information provided by the CAU team and other contacts, data and information around the amount of CT in China (in hectares), benefits and costs could be improved. This information has now been used in updating the Vere assumptions, to reflect a more accurate account of what has happened since 2005.

It was also discovered that, due to the increased capacity in CT in China, equipment, knowledge and extension services are being exported to other countries in the Asian region. The scoping study did not capture this information. While the further capacity built was not a direct impact of the ACIAR investment, without the investment of ACIAR, these further developments might have been delayed or not have occurred.

Further information from the field trips was assembled. For example, burning of straw residue has significantly decreased, after provincial government made it illegal—this information was confirmed from discussions from numerous stakeholders.

While CT adoption has grown since the completion of the ACIAR project, there is still some non-adoption of CT by farmers, due to tradition, problems with germination, pests, diseases, and blockages from straw retention.

The counterfactual scenario was further elaborated during the field trip. Before the trip, it was understood that the ACIAR investment was important for CT adoption and development in China. During the field trip, from discussions with the different stakeholders, it became clear that without the ACIAR project adoption of CT in China would have been delayed by 5–10 years. This is longer than the Vere assumption of a 3-year lag in adoption.

The achievements of CAU and the Conservation Tillage Research Centre have been widely recognised since the Vere assessment. Awards have been given, with the CAU team receiving national awards, as well as recognition by high-ranking politicians of the benefits of CT.

Overall, the field trip yielded significant information, and contacts met during the field trip provided data that were needed to fill information gaps identified in the scoping study, as well as further information necessary to update Vere's 2005 impact assessment.

No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Centre for International Economics 1998	Control of Newcastle disease in village chickens	AS1/1983/034, AS1/1987/017, AS1/1993/222
2	George P.S. 1998	Increased efficiency of straw utilisation by cattle and buffalo	AS1/1982/003, AS2/1986/001, AS2/1988/017
3	Centre for International Economics 1998	Establishment of a protected area in Vanuatu	ANRE/1990/020
4	Watson A.S. 1998	Raw wool production and marketing in China	ADP/1988/011
5	Collins D.J. and Collins B.A. 1998	Fruit fly in Malaysia and Thailand 1985–1993	CS2/1983/043, CS2/1989/019
6	Ryan J.G. 1998	Pigeonpea improvement	CS1/1982/001, CS1/1985/067
7	Centre for International Economics 1998	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	FIS/1991/030
8	McKenney D.W. 1998	Australian tree species selection in China	FST/1984/057, FST/1988/048
9	ACIL Consulting 1998	Sulfur test KCL–40 and growth of the Australian canola industry	PN/1983/028, PN/1988/004
10	AACM International 1998	Conservation tillage and controlled traffic	LWR2/1992/009
11	Chudleigh P. 1998	Postharvest R&D concerning tropical fruits	PHT/1983/056, PHT/1988/044
12	Waterhouse D., Dillon B. and Vincent D. 1999	Biological control of the banana skipper in Papua New Guinea	CS2/1988/002-C
13	Chudleigh P. 1999	Breeding and quality analysis of rapeseed	CS1/1984/069, CS1/1988/039
14	McLeod R., Isvilanonda S. and Wattanutchariya S. 1999	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008, PHT/1990/008
15	Chudleigh P. 1999	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod R. 2001	Control of footrot in small ruminants of Nepal	AS2/1991/017, AS2/1996/021
17	Tisdell C. and Wilson C. 2001	Breeding and feeding pigs in Australia and Vietnam	AS2/1994/023
18	Vincent D. and Quirke D. 2002	Controlling *Phalaris minor* in the Indian rice-wheat belt	CS1/1996/013
19	Pearce D. 2002	Measuring the poverty impact of ACIAR projects—a broad framework	
20	Warner R. and Bauer M. 2002	*Mama Lus Frut* scheme: an assessment of poverty reduction	ASEM/1999/084
21	McLeod R. 2003	Improved methods in diagnosis, epidemiology, and information management of foot-and-mouth disease in South-East Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004, AS1/1994/038

No.	Author(s) and year of publication	Title	ACIAR project numbers
22	Bauer M., Pearce D. and Vincent D. 2003	Saving a staple crop: impact of biological control of the banana skipper on poverty reduction in Papua New Guinea	CS2/1988/002-C
23	McLeod R. 2003	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011, AS2/1993/001
24	Palis F.G., Sumalde Z.M. and Hossain M. 2004	Assessment of the rodent control projects in Vietnam funded by ACIAR and AusAID: adoption and impact	AS1/1998/036
25	Brennan J.P. and Quade K.J. 2004	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037, CS1/1988/014
26	Mullen J.D. 2004	Impact assessment of ACIAR-funded projects on grain-market reform in China	ADP/1997/021, ANRE1/1992/028
27	van Bueren M. 2004	Acacia hybrids in Vietnam	FST/1986/030
28	Harris D. 2004	Water and nitrogen management in wheat-maize production on the North China Plain	LWR1/1996/164
29	Lindner R. 2004	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081
30	van Bueren M. 2004	Eucalypt tree improvement in China	FST/1984/057, FST/1987/036, FST/1988/048, FST/1990/044, FST/1994/025, FST/1996/125, FST/1997/077
31	Pearce D. 2005	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce D. 2005	Shelf-life extension of leafy vegetables—evaluating the impacts	PHT/1994/016
33	Vere D. 2005	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce D. 2005	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer D.A. and Lindner R. 2005	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner R. 2005	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017, FIS/1999/076
37	McLeod R. 2005	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225
38	ACIAR 2006	Future directions for ACIAR's animal health research	

No.	Author(s) and year of publication	Title	ACIAR project numbers
39	Pearce D., Monck M., Chadwick K. and Corbishley J. 2006	Benefits to Australia from ACIAR-funded research	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060, CS1/1990/012, CS1/1994/968, FST/1993/016, PHT/1990/051
40	Corbishley J. and Pearce D. 2006.	Zero tillage for weed control in India: the contribution to poverty alleviation	CS1/1996/013
41	ACIAR 2006	ACIAR and public funding of R&D. Submission to Productivity Commission study on public support for science and innovation	
42	Pearce D. and Monck M. 2006	Benefits to Australia of selected CABI products	
43	Harris D.N. 2006	Water management in public irrigation schemes in Vietnam	LWR1/1998/034, LWR2/1994/004
44	Gordon J. and Chadwick K. 2007	Impact assessment of capacity building and training: assessment framework and two case studies	CS1/1982/001, CS1/1985/067, LWR2/1994/004, LWR2/1998/034
45	Turnbull J.W. 2007	Development of sustainable forestry plantations in China: a review	
46	Monck M. and Pearce D. 2007	Mite pests of honey bees in the Asia–Pacific region	AS2/1990/028, AS2/1994/017, AS2/1994/018, AS2/1999/060
47	Fisher H. and Gordon J. 2007	Improved Australian tree species for Vietnam	FST/1993/118 and FST/1998/096
48	Longmore C., Gordon J. and Bantilan M.C. 2007	Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia	CS1/1994/968
49	Fisher H. and Gordon J. 2007	Minimising impacts of fungal disease of eucalypts in South-East Asia	FST/1994/041
50	Monck M. and Pearce D. 2007	Improved trade in mangoes from the Philippines, Thailand and Australia	CS1/1990/012, PHT/1990/051
51	Corbishley J. and Pearce D. 2007	Growing trees on salt-affected land	FST/1993/016
52	Fisher H. and Gordon J. 2008	Breeding and feeding pigs in Vietnam: assessment of capacity building and an update on impacts	AS2/1994/023
53	Monck M. and Pearce D. 2008	The impact of increasing efficiency and productivity of ruminants in India by the use of protected nutrient technology	AH/1997/115
54	Monck M. and Pearce D. 2008	Impact of improved management of white grubs in peanut-cropping systems in India	CS2/1994/050

No.	Author(s) and year of publication	Title	ACIAR project numbers
55	Martin G. 2008	ACIAR fisheries projects in Indonesia: review and impact assessment	FIS/1997/022, FIS/1997/125, FIS/2000/061, FIS/2001/079, FIS/2002/074, FIS/2002/076, FIS/2005/169, FIS/2006/144
56	Lindner B. and McLeod P. 2008	A review and impact assessment of ACIAR's fruitfly research partnerships—1984–2007	CP/1997/079, CP/2001/027, CP/2002/086, CP/2007/002, CP/2007/187, CS2/1983/043, CS2/1989/019, CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225, CS2/1997/101, CS2/1998/005, CS2/2003/036, PHT/1990/051, PHT/1993/87, PHT/1994/133
57	Montes N.D., Zapata Jr N.R., Alo A.M.P. and Mullen J.D. 2008	Management of internal parasites in goats in the Philippines	AS1/1997/133
58	Davis J., Gordon J., Pearce D. and Templeton D. 2008	Guidelines for assessing the impacts of ACIAR's research activities	
59	Chupungco A., Dumayas E. and Mullen J. 2008	Two-stage grain drying in the Philippines	PHT/1983/008, PHT/1986/008, PHT/1990/008
60	Centre for International Economics 2009	ACIAR Database for Impact Assessments (ADIA): an outline of the database structure and a guide to its operation	
61	Fisher H. and Pearce D. 2009	Salinity reduction in tannery effluents in India and Australia	AS1/2001/005
62	Francisco S.R., Mangabat M.C., Mataia A.B., Acda M.A., Kagaoan C.V., Laguna J.P., Ramos M., Garabiag K.A., Paguia F.L. and Mullen J.D. 2009	Integrated management of insect pests of stored grain in the Philippines	PHT/1983/009, PHT/1983/011, PHT/1986/009, PHT/1990/009
63	Harding M., Tingsong Jiang and Pearce D. 2009	Analysis of ACIAR's returns on investment: appropriateness, efficiency and effectiveness	
64	Mullen J.D. 2010	Reform of domestic grain markets in China: a reassessment of the contribution of ACIAR-funded economic policy research	ADP/1997/021 and ANRE1/1992/028
65	Martin G. 2010	ACIAR investment in research on forages in Indonesia	AS2/2000/103, AS2/2000/124, AS2/2001/125, LPS/2004/005, SMAR/2006/061, SMAR/2006/096
66	Harris D.N. 2010	Extending low-cost fish farming in Thailand: an ACIAR–World Vision collaborative program	PLIA/2000/165
67	Fisher H. 2010	The biology, socioeconomics and management of the barramundi fishery in Papua New Guinea's Western Province	FIS/1998/024

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No.	Author(s) and year of publication	Title	ACIAR project numbers
68	McClintock A. and Griffith G. 2010	Benefit–cost meta-analysis of investment in the International Agricultural Research Centres	
69	Pearce D. 2010	Lessons learned from past ACIAR impact assessments, adoption studies and experience	
70	Harris D.N. 2011	Extending low-chill fruit in northern Thailand: an ACIAR–World Vision collaborative project	PLIA/2000/165
71	Lindner R. 2011	The economic impact in Indonesia and Australia from ACIAR's investment in plantation forestry research, 1987–2009	FST/1986/013, FST/1990/043, FST/1993/118, FST/1995/110, FST/1995/124, FST/1996/182, FST/1997/035, FST/1998/096, FST/2000/122, FST/2000/123, FST/2003/048, FST/2004/058
72	Lindner R. 2011	Frameworks for assessing policy research and ACIAR's investment in policy-oriented projects in Indonesia	ADP/1994/049, ADP/2000/100, ADP/2000/126, AGB/2000/072, AGB/2004/028, ANRE1/1990/038, ANRE1/1993/023, ANRE1/1993/705, EFS/1983/062, EFS/1988/022
73	Fisher H. 2011	Forestry in Papua New Guinea: a review of ACIAR's program	FST/1994/033, FST/1995/123, FST/1998/118, FST/2002/010, FST/2004/050, FST/2004/055, FST/2004/061, FST/2006/048, FST/2006/088, FST/2006/120, FST/2007/078, FST/2009/012
74	Brennan J.P. and Malabayabas A. 2011	International Rice Research Institute's contribution to rice varietal yield improvement in South-East Asia	
75	Harris D.N. 2011	Extending rice crop yield improvements in Lao PDR: an ACIAR–World Vision collaborative project	CIM/1999/048, CS1/1995/100, PLIA/2000/165
76	Grewal B., Grunfeld H. and Sheehan P. 2011	The contribution of agricultural growth to poverty reduction	
77	Saunders C., Davis L. and Pearce D. 2012	Rice–wheat cropping systems in India and Australia, and development of the 'Happy Seeder'	LWR/2000/089, LWR/2006/132, CSE/2006/124
78	Carpenter D. and McGillivray M. 2012	A methodology for assessing the poverty-reducing impacts of Australia's international agricultural research	
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