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Australian Centre for International Agricultural Research

ACIAR-funded crop–livestock projects, Tibet Autonomous Region, People's Republic of China

ACIAR IMPACT ASSESSMENT SERIES 88

Research that works for developing countries and Australia

ACIAR-funded crop–livestock projects, Tibet Autonomous Region, People’s Republic of China

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2015

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Clarke M. 2015. ACIAR-funded crop–livestock projects, Tibet Autonomous Region, People's Republic of China. ACIAR Impact Assessment Series Report No. 88. Australian Centre for International Agricultural Research: Canberra. 56 pp.

ACIAR Impact Assessment Series – ISSN 1832-1879 (print), ISSN 1839-6097 (online)

ISBN 978 1 925133 55 4 (print)
ISBN 978 1 925133 56 1 (PDF)

Editing by Mason Edit, Adelaide
Design by Peter Nolan
Cover photo: Bonnie Flohr

Foreword

Since 2002 nine ACIAR projects have broadly targeted the crop–livestock zone in Tibet Autonomous Region (TAR), China, where the challenges of land degradation, access to water and poor agricultural practices result in low crop productivity and poor animal condition. This impact assessment study has selected four of these projects, which were designed to improve outcomes for women and families who are smallholder farmers growing crops and raising cattle in the lower altitude prefectures of Shannan and Lhasa (3,500–3,700 metres) and the higher altitude Xigaze Prefecture (3,800–4,000 metres).

The study has highlighted some significant gains. For instance, relay sowing of vetch in winter wheat and barley crops can generate fodder without sacrificing food security—a gain for the crop–livestock zone at lower altitudes. In higher altitude areas farmers have intensified barley production and set aside arable land for oats and triticale to produce fodder. In both zones cereal haymaking has been augmented with more-nutritious species, and dairy cattle nutrition has improved through better preparation of fodder, provision of adequate water and the addition of mineral concentrates. The study also highlighted the gains from shifting to high-butterfat Jersey cattle and away from less-suitable Holstein and Simmental breeds in the higher altitudes. Overall success emerging from the adoption of technologies can be gauged in higher milk production, more calves raised and fewer losses of cows as a result of poor nutrition.

The strong collaboration within the projects has been a significant element in the successful delivery of project outputs. ACIAR's TAR partners have further developed and extended initial outputs using participatory approaches and micro-extension techniques. The communication of successes to other TAR organisations has resulted in commitment of substantial funding for further extension, and support for the purchase of inputs that will assist farmers in taking up the ACIAR recommendations. Already, 10% of farms in the crop–livestock zone have adopted the research outputs, and this is forecast to increase by 3–5% yearly in the medium term.

ACIAR values highly the hallmarks of success through capacity building among the scientists of its collaborating institutions. Local scientists who learnt through their involvement in the projects are now leading the way in adoption and extension. Agricultural systems thinking is the new norm. The compelling communication of outputs by local scientists to the TAR Poverty Alleviation Office and the Central Government Finance Department have given these entities the confidence to invest in the project technologies, and this move is already having social and environmental benefits for the farmers. This study emphasises that capacity building will be the long-lasting legacy of this 12-year involvement.

In terms of economic impact, the study has calculated the significant economic benefits that the four ACIAR projects have delivered to these poor, largely subsistence communities in TAR. The assessors have determined a 15:1 cost:benefit ratio over a 30-year period, which is an exceptional return on investment. Undoubtedly the most pleasing aspect of these findings is that the economic benefits created will flow mainly to women and families who are smallholder fodder and dairy producers.

Nick Austin
Chief Executive Officer, ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AI	artificial insemination
AYAD	Australian Youth Ambassador for Development
CRC	Cooperative Research Centre
CGRD	Central Government Finance Department
DFAT	Department of Foreign Affairs and Trade (Australia)
DAAH	Department of Agriculture and Animal Husbandry (TAR)
DPI	Department of Primary Industries (New South Wales)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
IAS	impact assessment study
mu	area of measurement in China (1 ha = 15 mu)
PAO	Poverty Alleviation Office (TAR)
PIRDP	Panam Integrated Rural Development Project
PRC	People's Republic of China
RD&E	research, development and extension
TLRI	Tibet Livestock Research Institute, TAAAS
TAAAS	Tibet Academy of Agriculture and Animal Husbandry Sciences
TAR	Tibet Autonomous Region
TARI	Tibet Agricultural Research Institute, TAAAS
Y	yuan (currency of the PRC)

Acknowledgments

The author gratefully acknowledges the following:

Dr Andrew Alford, Research Program Manager, Impact Assessment, ACIAR; Dr Peter Horne, General Manager Country Programs, ACIAR; and Wang Guanglin, Country Manager China, ACIAR.

In China the author would like to thank Wang Jian, Deputy Director of the TAR Poverty Alleviation Office; Dr Nyima Tashi, Vice President, Tibet Academy of Agriculture and Animal Husbandry Sciences; Jin Tao, Associate Professor, Tibet Agricultural Research Institute; Pubu Drolma, Tibet Agricultural Research Institute; Dr Nyima Tsamyu, Deputy Director, Tibet Livestock Research Institute; and Winjin Cuomu, Scientist, Tibet Livestock Research Institute.

Prior to completion of the field investigation, assistance was provided by project researchers Dr John Wilkins, John Piltz, Professor David Coventry and Associate Professor Colin Brown. Insight was also provided by Bonnie Flohr, Australian Youth Ambassador for Development.

Dr John Mullen, Economic Impact Assessment Specialist, assisted with development and execution of the economic impact framework.

Executive summary

This document is an impact assessment study (IAS) of four ACIAR-funded projects in Tibet Autonomous Region (TAR) of the People's Republic of China. The four project titles are 'Increasing milk production from cattle, TAR' (LPS/2002/104); 'Intensifying production of grain and fodder in central TAR farming systems' (CIM/2002/093); 'Integrating crop and dairy systems in TAR' (LPS/2006/119); and 'Improving the mineral nutrition of TAR livestock' (LPS/2010/028).

Project objectives were to:

- LPS/2002/104: Improve Tibetan dairy cow nutrition, and increase milk production and household income for smallholder farmers
- CIM/2002/093: Produce additional livestock fodder without compromising grain production (grain is only used to sustain the human population)
- LPS/2006/119: Confirm and extend the results of LPS/2002/104 and CIM/2002/093
- LPS/2010/028: Understand the impact of mineral deficiencies on livestock, assess livestock response to mineral supplementation and assist with the development of a sustainable mineral supplement industry for TAR livestock.

Outputs delivered by ACIAR-funded research

Project outputs target the TAR's crop–livestock zone. Outputs are tailored to the lower altitude prefectures of Shannan and Lhasa (3,500 m to 3,700 m), as well as the higher altitudes of the large Xigaze (3,800 m to 4,000 m) Prefecture.

Research outputs include:

- relay sowing of vetch in winter wheat and barley crops to generate fodder without sacrificing food security in the lower altitudes in the crop–livestock zone
- intensifying barley production and setting aside arable land for fodder oats and triticale in the higher altitude areas of the crop–livestock zone
- additional haymaking that includes augmentation of cereal straw with more-nutritious vetch and oats/triticale, which is relevant to both lower and higher prefectures
- adoption of techniques to improve dairy nutrition including the chopping of straw to a more suitable length, providing adequate stock water and supplementing fodder with concentrates
- shifting to high-butterfat Jersey genetics from poorly suited Holstein and Simmental dairy cows in the higher altitude Xigaze Prefecture.

Adoption and outcomes

ACIAR has partnered with the Tibet Academy of Agriculture and Animal Husbandry Sciences (TAAAS), the Tibet Agricultural Research Institute (TARI) and the Tibet Livestock Research Institute (TLRI) to deliver crop–livestock projects. TARI and TLRI have further developed and extended initial outputs from ACIAR research using participatory approaches and micro-extension techniques. TARI and TLRI have communicated project successes to

TAAAS, the TAR Poverty Alleviation Office (PAO) and the Central Government Finance Department (CGFD). Communication of research, development and extension successes has resulted in the securing of substantial funding for further extension and support for the purchase of farm inputs (e.g. vetch seed distributed to largely subsistence smallholders at no cost). In 2014 TARI and TLRI reported that an estimated 10% of farms in the crop–livestock zone adopted ACIAR research outputs, and adoption is forecast to increase by 3%–5% per year over the medium term. Economic modelling employed in the IAS has used a more conservative adoption rate.

Outcomes from ACIAR project adoption include an increase in milk production, an increase in calves raised and fewer losses of cows as a result of poor nutrition. While adoption of research outputs has resulted in additional work for rural women, the extra income generated has assisted with the tertiary education of their children and the purchase of labour-saving consumer durables. Adoption of the legume vetch as a relay crop assists with the fertility of soils, and intensification of fodder production takes pressure off easily eroded rangeland grazing. The extent of any recovery in rangeland ecosystems will be determined by the willingness of Tibetan livestock officers to enforce breaches in grazing quotas.

Drivers of adoption

Adoption of research outputs has been driven by Tibetan scientists who developed capacity through the projects; project data that gave PAO and CGFD the confidence to invest in project technologies; free inputs to facilitate adoption (e.g. seed and training); and large-scale investments including infrastructure to support adoption (e.g. artificial insemination of dairy cattle, fodder stores, irrigation systems, roads to market).

Economic impacts

Projects funded by the Australian Government through ACIAR have delivered significant economic benefits to poor, largely subsistence, communities in TAR.

Summary of IAS project returns

Criterion	Total investment in IAS projects	ACIAR investment in IAS projects
Present value of benefits ($A million)	125.01	65.03
Present value of costs ($A million)	8.28	4.30
Net present value ($A million)	116.73	60.73
Benefit:cost ratio	15.10	15.13

Note: A discount rate of 5% has been used

The total investment of $A8.28 million (present value terms) from ACIAR and its research partners in the four IAS projects has been estimated to produce gross benefits of $A125.01 million (present value terms), providing a net present value of $A116.73 million and a benefit:cost ratio of 15.1:1 (over 30 years using a 5% discount rate). The ACIAR investment has been successful. The economic benefits created from the ACIAR projects are estimated to flow mainly to smallholder fodder and dairy producers.

Capacity building and Australian impacts

Capacity building will be the long-lasting legacy of the ACIAR projects. Scientific, project management and institutional design skills that have been developed in TAR nationals have been successfully applied to TAR projects reviewed in this impact assessment and other research projects. In turn, the transfer of skills to others in TAR has started the process of shifting agricultural research capacity in the region toward best practice.

Australia has also benefited from ACIAR's investment in the TAR projects reviewed in this IAS. New skills have been created in agricultural development and new knowledge generated in the use of Australian cereal straws in combination with vetch and lucerne to produce low-cost and nutritious cattle feed.

Conclusions

The ACIAR-funded research has provided substantial net benefits for poor rural farmers in TAR. Spillovers include capacity building, social and environmental benefits, and gains in skills and knowledge in Australia.

1 Introduction

Background

This impact assessment study (IAS) is of a cluster of Australian Centre for International Agricultural Research (ACIAR)-funded projects completed in the crop–livestock zone of Tibet Autonomous Region (TAR) of the People's Republic of China (PRC)[1].

ACIAR has placed significant emphasis on assessment of the impact of the research it funds, particularly focusing on quantifying the returns to research investments by measuring adoption and impacts. IASs provide insight on the efficiency and effectiveness of ACIAR activities. ACIAR uses IASs to account to its stakeholders and to support improved decision-making, priority setting, resource allocation and project design. Through impact assessment ACIAR continually improves delivery of its objectives.

ACIAR's program in PRC targets strategic partnerships and improvement in the sustainability of agricultural production. Partnerships are forged with, for example, the PRC Ministry of Science and Technology and Ministry of Agriculture and Water Resources, as well as the Chinese Academy of Sciences, Chinese Academy of Agricultural Sciences, universities, and provincial academies and authorities. The TAR academy most relevant to this IAS was the Tibet Academy of Agriculture and Animal Husbandry Sciences (TAAAS) and two of its specialist institutes: the Tibet Agricultural Research Institute (TARI) and the Tibet Livestock Research Institute (TLRI). The TAR Poverty Alleviation Office (PAO), a major funder of TAAAS research, funds adoption of research outputs, and the Central Government Finance Department (CGFD) funds implementation of research outputs. In recognition of China's increasing financial resources, all ACIAR activities in PRC involve substantial collaboration and co-investment from Chinese partners.

ACIAR research in PRC focuses on policy and technical issues associated with better management of land and water resources in north-western China and crop–livestock systems in TAR. In addressing land and water resource use issues, the need to raise farmers' incomes through increased productivity and marketability of produce is also covered in research design. To reach those most affected by poverty and land degradation, the program increasingly targets dryland crop–livestock systems.

The priorities for ACIAR's PRC program articulated through the Annual Operating Plan 2013–14 are:

- selection of technologies for improved water-use efficiency, with an emphasis on dryland agriculture
- development of policies and institutions for improved land and water use and associated climate change influences
- integrated crop–livestock systems in favourable areas of TAR and the rangelands of north-western China.

Terms of reference

This IAS required a detailed analysis of crop–livestock project inputs, outputs and outcomes. It included

[1] TAR is used throughout this report to refer to Tibet Autonomous Region of the People's Republic of China. 'Tibetan' is also used to refer to livestock, people and agencies originating in TAR.

impact pathway analysis in which impacts were assessed for both TAR and Australia.

The analysis provided quantitative estimates of the return on investment from a cluster of crop–livestock projects. Qualitative assessment of social and environmental impacts and capacity building was also completed.

Of particular interest to this IAS were the identification and characterisation of key drivers of adoption of the projects' outputs, and the key linkages between researchers and next users of research outputs that have been necessary for adoption to occur.

IAS objectives were to:

1. analyse inputs, outputs and outcomes from the TAR crop–livestock projects
2. determine the drivers of output adoption and document the key linkages created
3. quantify the economic benefits for TAR and Australia
4. identify and describe the social impacts associated with the projects
5. identify and describe the environmental impacts of the projects
6. (provide an impact assessment report suitable for publication by ACIAR).

Impact assessment methods and activities

The IAS was completed using the *Guidelines for assessing the impacts of ACIAR's research activities* (Davis et al. 2008) and ACIAR's Impact Assessment Framework (Figure 1.1).

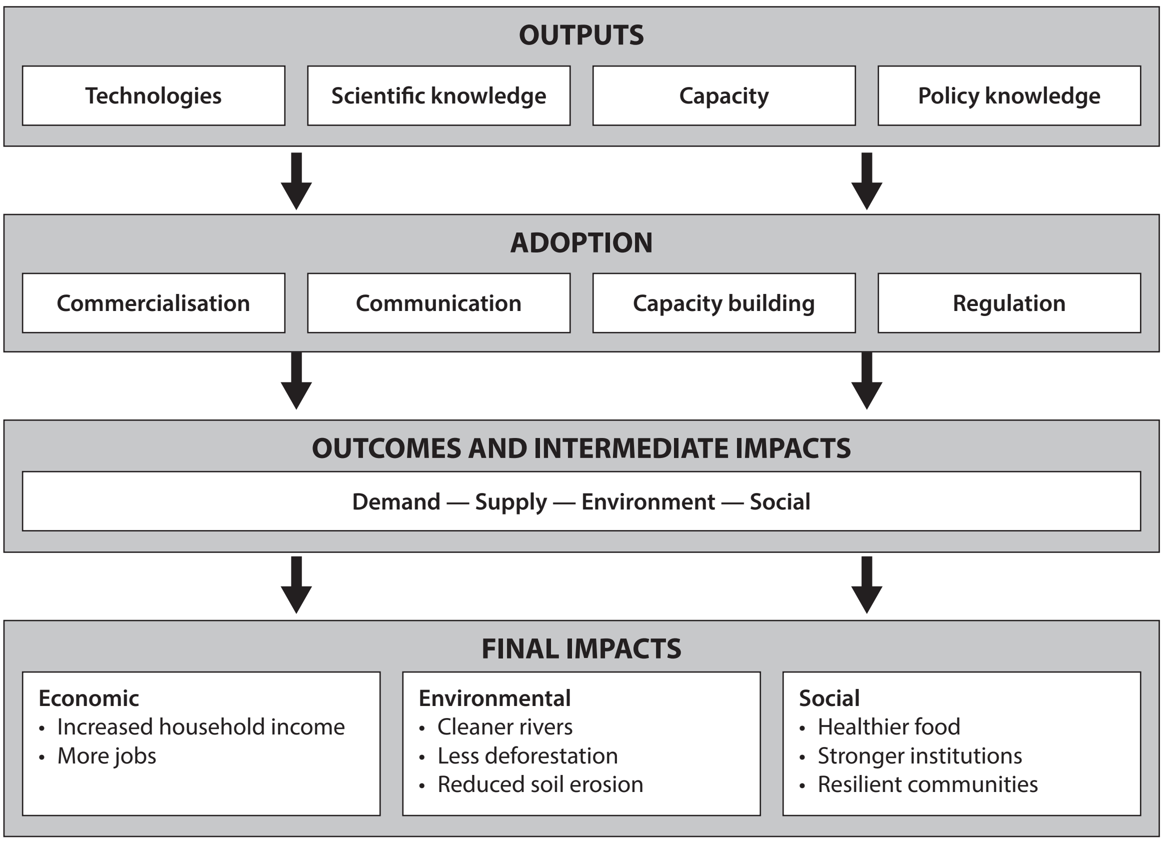

Figure 1.1 ACIAR Impact Assessment Framework. Source: ACIAR 2014

An understanding of the Impact Assessment Framework was developed via best practice examples (e.g. *Impact pathway analysis of ACIAR's investment in rodent control in Vietnam, Lao and Cambodia* – Palis et al. 2013) and journal articles (e.g. Douthwaite et al. 2007).

Interviews were completed with partner research scientists in Australia and in-country. Fieldwork for this impact assessment was completed in TAR and Beijing between 27 August 2014 and 9 September 2014.

Report structure

The report has the following structure:

- Section 2 defines the ACIAR's crop–livestock project cluster for analysis.
- Section 3 summarises ACIAR, partner and other investments in the IAS projects.
- Section 4 provides a project and farm enterprise description including location, justification and aims.
- Section 5 contains the impact pathway analysis including adoption drivers and a description of linkages between researchers and next users of research outputs.
- Section 6 comprises analysis of project impacts including science and capacity building; and economic, social and environmental impacts for TAR and Australia.
- Section 7 details the IAS conclusions.

A list of references used in the IAS is also included along with a list of publications produced by the IAS projects.

2 ACIAR's crop–livestock projects in TAR

TAR crop–livestock projects

The Australian Government has invested in agricultural development projects in TAR since 2002. A list of relevant ACIAR and Department of Foreign Affairs and Trade (DFAT) projects is provided in Table 2.1.

In addition to Australian-funded projects, other international and domestic agencies have contributed to crop–livestock development objectives in TAR. For example, a joint European Union (EU) – China program in Panam County (Panam Integrated Rural Development Project (PIRDP) – Program No. ALA/CHN/94/19) covered all aspects of community development including field evaluation of alternative forages, training courses for extension staff and training for farmers in various aspects of animal production (Kaiser et al. 2004).

The Food and Agriculture Organization of the United Nations (FAO) funded a technical cooperation project addressing double cropping and zero tillage in TAR in the mid 2000s (Lane 2006). In interviews with TARI staff it was evident that capacity was developed by contributing to PIRDP, FAO and ACIAR projects. PAO has funded the 'scaling up' and widespread adoption of outputs from ACIAR projects.

PAO rural development investments in the TAR crop–livestock zone that utilise ACIAR project outputs include provision of fodder crop seed, fertiliser, dairy genetics, tractors, irrigation systems, greenhouses, grain storage sheds, animal sheds and farm housing. PAO works in partnership with CGFD in the provision of schools and major infrastructure such as roads and bridges. In 2012 and 2013 CGFD contributed funding to the construction of a factory to manufacture livestock mineral supplementation blocks using recipes created as part of an ACIAR project.

It is difficult to obtain a complete picture of crop–livestock development projects in central TAR. Certainly, Canada though CEDA has made investments in cropping and livestock improvement in central TAR since 2003, but was refused the opportunity to extend its program by TAR authorities. Furthermore, it is difficult to clearly separate development assistance directly contributing to crop–livestock projects rather than more-generic development goals. It has been essential to account for other crop–livestock development initiatives and associated rural development investments when attributing benefits to IAS projects.

IAS projects

This IAS focuses on four closely linked ACIAR TAR crop–livestock projects:

- LPS/2002/104 Increasing milk production from cattle in TAR
- CIM/2002/093 Intensifying production of grain and fodder in central TAR farming systems
- LPS/2006/119 Integrated crop and dairy systems in TAR, PRC
- LPS/2010/028 Improving the mineral nutrition of Tibetan livestock.

Investments made by ACIAR and its research partners in these projects are shown in Tables 3.1 and 3.2. In parallel with the ACIAR projects, the PRC Government and international agencies made a number of related research, development and extension (RD&E) investments. These were identified by researchers during this study and totalled approximately $3 million (nominal AU$) between 2005 and 2012 (Table 3.3).

Table 2.1 Australian-funded agricultural projects in TAR relevant to this IAS

Title	Number	Reference	Years
Increasing milk production from cattle in TAR	LPS/2002/104	Wilkins and Piltz (2008)	2004–07
Intensifying production of grain and fodder in central TAR farming systems	CIM/2002/093	Paltridge, Coventry, Tao and Tashi (2008)	2004–07
Mineral nutrition of livestock in TAR (I & II)	LPS/2005/018	Tashi, Xugang, Shunxiang and Judson (2005)	2003–05
Mineral response in Tibetan livestock	LPS/2005/129	Spiegel and Costa (2014)	2007–10
Integrated crop and dairy systems in Tibet Autonomous Region, PR China	LPS/2006/119	McNeill, Wilkins and Piltz (2014)	2008–12
Sustainable livestock grazing systems on Chinese temperate grasslands [a]	LPS/2008/048	Kemp (in progress)	2011–15
Improving the mineral nutrition of Tibetan livestock	LPS/2010/028	Spiegel and Costa (2014)	2011–14 (DFAT-funded)
Report for ACIAR on minerals in crops, livestock and humans in Tibet	C2012/228 [b]	Lyons (2013)	2013
Economic effects of mineral supplementation in crop–livestock systems in Tibet	C2013/017 [b]	Waldron and Brown (2013)	2013–14

Source: adapted from Spiegel and Costa (2014)

[a] A project based in China but associated with the DFAT-funded project LPS/2010/028

[b] Small Research and Development Activity; ACIAR contract number

3 Research investment

ACIAR research investments in IAS projects

ACIAR has invested approximately $A3 million in four TAR crop–livestock projects commencing in 2004–05 (Table 3.1).

Partner investments in IAS projects

Over the 8 years ending 30 June 2012, $A5.7 million was invested by ACIAR and its partners in IAS projects. ACIAR's share of total project investment was 52% (Table 3.2).

Table 3.1 Investments by ACIAR by project for years ending June 2005 to June 2012 (nominal $AUD)

Project	2005	2006	2007	2008	2009	2010	2011	2012	Total
LPS/2002/104	131,006	202,170	89,473						422,648
CIM/2002/093	195,712	118,602	61,387						375,701
LPS/2006/119				134,665	417,565	438,615	325,249	348,408	1,664,502
LPS/2010/028							156,166	363,376	519,542
Total	326,718	320,772	150,860	134,665	417,565	438,615	481,415	711,784	2,982,393

Table 3.2 Investments by ACIAR partners by project for years ending June 2005 to June 2012 (nominal $AUD)

Project	2005	2006	2007	2008	2009	2010	2011	2012	Total
LPS/2002/104	102,302	150,906	111,546						364,754
CIM/2002/093	244,319	167,766	86,593						498,678
LPS/2006/119				129,719	276,269	227,381	243,490	214,564	1,091,423
LPS/2010/028							260,319	529,157	789,476
Total	346,621	318,672	198,139	129,719	276,269	227,381	503,809	743,721	2,744,331

Note: includes Australian research provider funds as well as funds from TAAAS and the Chinese Academy of Agriculture

Parallel RD&E investments

In addition to investment in ACIAR projects, a further $A3 million in related research has been invested by the European Union (EU), FAO, PAO and CGFD (Table 3.3). PAO and CGFD investments relate only to crops, livestock and minerals. Their total investment in TAR agriculture since 2010 has been 'orders of magnitude' greater.

The selected IAS projects are a subset of total investment in all projects listed in Table 2.1 and the other overseas and domestic investments described in Table 3.3. They were chosen because together they formed a rational cluster of investments; that is, crop intensification to provide opportunity for fodder production, simple dairy nutrition and mineral supplements to improve dairy yields.

The total costs of projects along with parallel investments, further development, extension and implementation costs are included in the economic impact assessment.

Table 3.3 Approximate investment in parallel projects relevant to the IAS (nominal $AUD)

Project	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
EU				40,000	40,000	40,000	40,000	40,000		200,000
FAO	280,000	140,000								420,000
PAO						1,200,000	1,000,000			2,000,000
Finance								200,000	200,000	400,000
Total	280,000	140,000	0	40,000	40,000	1,240,000	1,040,000	240,000	200,000	3,020,000

Note: EU and PAO project commitments only include those funds that relate to fodder and milk production (Dr Nyima Tashi, pers. comm., 6 September 2014)

4 IAS project location and description

Location of IAS projects and farm enterprise description

IAS projects were located in the central crop–livestock zone of TAR (Figure 4.1).

The central crop–livestock zone includes 18 counties and contains half of the TAR's 2.9 million people. Major population centres include Lhasa (population 400,000), Shigatse (100,000) and Tzedang (90,000). The zone is located at altitudes of between 3,500 m and 4,000 m in the river valleys of the middle reaches of the Yalongzangpo River and its two tributaries, the Lhasa River and Nyachu River. Approximately 80% of the zone's farm area is allocated to irrigated barley and wheat production. The balance is made up of a range of other crops including canola, faba beans, maize, vegetables, potatoes and fodder. The zone is stocked with 18 million ruminants—cattle, sheep, goats and yak/yak crosses. The crop–livestock zone is home to 890,000 head of cattle (Kaiser et al. 2004).

The TAR Government's main development objective for the crop–livestock zone has been to maintain grain yield while lifting livestock production through more-effective use of the cropping area and increased forage production (TAAAS 10th Five Year Plan).

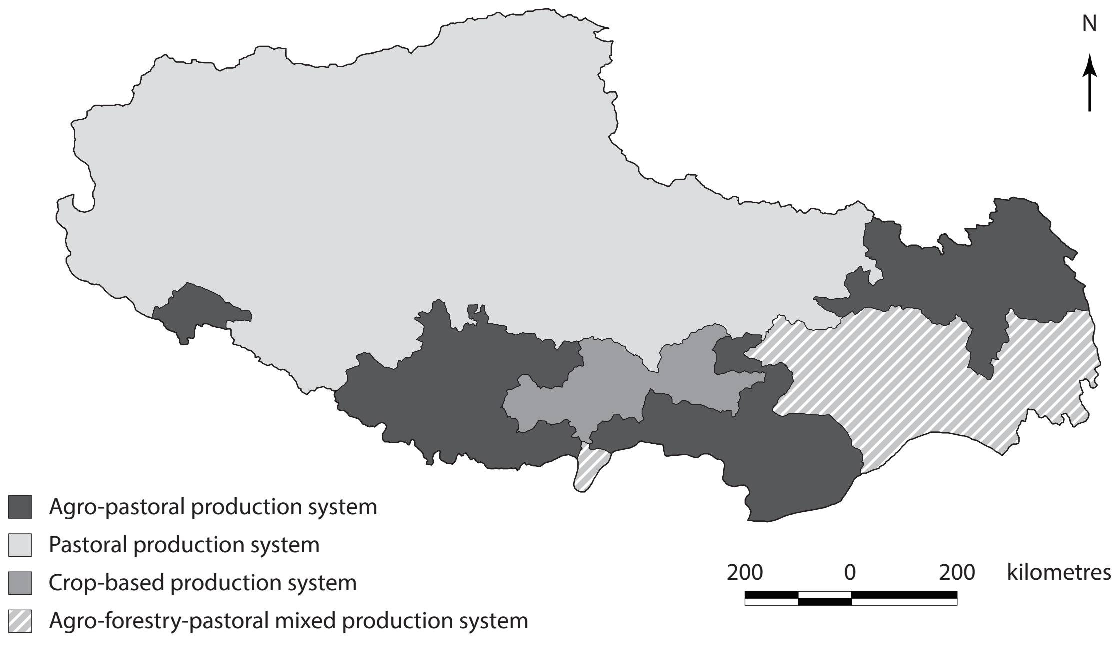

Figure 4.1 Project location—central crop–livestock zone. Source: Kaiser et al. (2004)

The 12th Five Year Plan (2014) and associated policies emphasise livestock productivity growth in the crop–livestock zone and a 50% reduction of livestock numbers in the pastoral zone. The overarching policy objective is to reduce poverty, increase incomes, increase food security and address degradation/agroenvironmental problems (ACIAR Concept Note TAR3 2014).

IAS projects focus on the lower altitude crop–livestock zone prefectures of Lhasa and Shannan and the higher altitude prefecture of Xigaze (Figure 4.2).

Table 4.1 summarises background and farm enterprise data on the two IAS project areas. Both Duopozhang and Bailang were visited during IAS field investigations in August and September 2014.

Relay cropping of vetch—generating the fodder base to improve cattle nutrition and increase milk production—is a critical component of the IAS projects. The farming calendar 'with' and 'without' the incorporation of relay cropping is shown as Figure 4.3.

Relay cropping takes advantage of both sunlight and residual soil water not currently being used for grain production, and produces much-needed fodder.

Increasing milk production from cattle, TAR (LPS/2002/104)

The aim of ACIAR project LPS/2002/104 was to improve dairy cow nutrition in order to increase milk production and household income.

Almost all households in the crop–livestock zone raise cattle. Cattle and grain production are highly integrated, typically on the one smallholding. Improving the productivity of the livestock component of smallholdings will increase family welfare and income. The development of better feeding systems will also reduce grazing pressure and land degradation in the nearby pastoral zone (Kaiser et al. 2004).

Dairy is the livestock production system with greatest potential in the crop–livestock zone. The consumption of milk, cheese, yoghurt and butter is part of the Tibetan culture—butter added to tea is a local staple. Dairy is a major own-consumption item and source of nutrition as well as revenue for farmers (Waldron and Brown 2013). Dairy is bartered for other goods and services within a village and small towns often have local yoghurt makers.

Figure 4.2 TAR county and prefecture map. Source: <www.tibettravelplanner.com/mapsoftibet.htm>

Table 4.1 Farm enterprise description, TAR crop–livestock zone

Attribute	Lower altitude	Higher altitude
Prefectures	Shannan Lhasa	Xigaze (includes Shigatse)
Key ACIAR project village/county	Duopozhang	Bailang
Altitude	3,500 m to 3,700 m	3,800 m to 4,000 m
No. of villages in prefecture	Shannan: 493 Lhasa: 224	Xigaze: 1,643
Farm numbers (approx.)	71,700 (100 smaller farms per village)	82,150 (50 larger farms per village)
Farm size (average)	14 mu (15 mu = 1 ha)	70 mu (15 mu = 1 ha)
Farm enterprises	Barley, winter wheat, vegetables; dairy with some sales to Tsetang and Lhasa	Barley (growing season too short for winter wheat); dairy with some sales to Shigatse
New farm enterprises linked to ACIAR projects	Relay cropping vetch with barley or winter wheat Hay of higher quality that combines protein and roughage Simple dairy nutrition recommendations including straw chop length, additional livestock water and concentrates Mineral augmentation	Intensification of grain growing, allowing allocation of some land to fodder crops of oats/triticale Hay of higher quality that combines protein and roughage Simple dairy nutrition recommendations including straw chop length, additional livestock water and concentrates Shift to Jersey dairy genetics from Holstein Mineral augmentation
Farms that have adopted ACIAR outputs in 2014	3,585 (5% of the farm population)	4,108 (5% of the farm population)

Source: Project consultation and Tibet Statistical Yearbook 2013

	O	N	D	J	F	M	A	M	J	J	A	S
‘Without’ relay cropping												
Spring barley	Sow										Harv	
Winter wheat	Sow									Harv		
‘With’ relay cropping												
Spring barley	Sow										Harv	
Winter wheat	Sow									Harv		
Vetch									Sow			Harv

Figure 4.3 Calendar of farm operations—‘with’ and ‘without’ relay cropping

Lhasa has a milk factory that produces pasteurised product, but transport from outlying villages to Lhasa is an issue (Wilkins and Piltz, New South Wales (NSW) Department of Primary Industries (DPI), pers. comm.)

TAR dairy has a partial commercial focus and a dairy marketing chain exists. Demand for milk and butter in Lhasa is growing at 20% per year and there is a shortage of milk products. Some 60% of Lhasa's winter milk and butter needs are met with imports from Inner Mongolia. Transport costs of $US200 per tonne (t) are incurred to bring milk and butter from Inner Mongolia to TAR (Kaiser et al. 2004).

Dairy cattle in the crop–livestock zone are malnourished, surviving on a diet of crop by-products and cereal straw. Per cow production of milk is less than genetic potential. Improving cow nutrition will improve reproductive performance, and increase survival and growth rates, milk yields and economic returns. Any increase in butterfat content in milk will increase the conversion coefficients of milk into butter, yoghurt and cheese (Colin Brown, University of Queensland, pers. comm.).

Simple strategies such as the treatment of straw before feeding (e.g. chopping to an optimal length), appropriate use of low-cost supplements (made locally from urea, grain and chopped straw), provision of adequate livestock water (at the cost of wet manure and difficulties drying dung for household fuel) and measures to avoid straw spoilage were all readily available and known to improve milk yield. Other strategies such as transitioning from Holstein to Jersey dairy genetics (lower fodder intake / additional butterfat), silage making and the development of annual feed budgets were also investigated.

The adoption of simple dairy improvement strategies has been shown to increase per head milk production in the crop–livestock zone from 5 kg/cow/day to 10 kg/cow/day. Additional calves are born and fewer calves and cows die (Dr Nyima Tsamyu, Director Animal Nutrition, TLRI, pers. comm.). Calves enjoy improved rates of growth, cows experience weight gain, milk is of a better colour (yellow rather than white), and the coats of cows are softer and thicker (Winjin Cuomu, Scientist, TLRI, pers. comm.).

Intensifying production of grain and fodder (CIM/2002/093)

At the same time as ACIAR was investing in dairy cow nutrition in the crop–livestock zone, a 'sister' ACIAR project (CIM/2002/093) was assessing the potential for intensifying the production of grain and fodder. The aim of this research was to produce additional fodder for livestock consumption without compromising grain production. Grain and fodder intensification research included the relay sowing (double cropping) of cereals and fodder species to increase fodder production without affecting grain supply.

Intensification options identified by the project included broadcast sowing of vetch (*Vicia sativa*) seed into maturing stands of winter wheat, and inter-row sowing of vetch and lucerne (*Medicago sativa*) into widely sown crops of winter wheat and barley. The first option, broadcasting vetch into stands of winter wheat, allowed for the production of around 3 t/ha of high-protein fodder with minimal impact on grain yield. The second option, inter-row sowing of vetch and lucerne, also allowed for the production of around 3 t/ha of vetch but led to grain yield reductions of between 16% and 37% (Paltridge et al. 2008).

The attractiveness of broadcast sowing of vetch was further enhanced by its minimal requirement for labour. Development options that require additional farm labour in the summer and autumn are less likely to be adopted. Female labour supply is constrained by other farm activities, and males seek off-farm employment during this time (David Coventry, The University of Adelaide, pers. comm.).

Integrated crop and dairy systems in TAR (LPS/2006/119)

Following completion of the dairy cow nutrition and crop intensification projects, a further ACIAR project (LPS/2006/119) examined various approaches, including community-based initiatives, to improve the overall productivity of the crop–dairy system in the crop–livestock zone (McNeill et al. 2014).

LPS/2006/119 was focused on the extension of research findings from LPS/2002/104 and CMS/2002/093 (David Coventry, The University of Adelaide, pers. comm.).

This project also researched agronomic options for forage production that would not reduce cereal grain yield. Feed intake and milk production were monitored to relate nutrient requirements to availability, and the risk of restriction was determined. Data generated by these experiments allowed the demonstration and promotion of principles and strategies for feed supplementation to improve animal health, nutrition and milk production (McNeill et al. 2014).

Production variables generated by the project were used to develop a socioeconomic optimisation model (CAEG Tibet) for Tibetan households, and this tool has been made available to TLRI to inform subsequent research and extension (McNeill et al. 2014). TLRI staff have been brought to Australia to receive further training in the use of the economic model (Wang Guanglin, ACIAR, pers. comm.).

The creation of credible and convincing data through this project provided the evidence base for PAO to incorporate relay cropping (double cropping) in its program of rural development initiatives in TAR. Adoption of double cropping has been immediate and widespread, facilitated by its low labour requirements and support from PAO, including free vetch seed and farmers being paid to attend training (David Coventry, The University of Adelaide, pers. comm.).

Improving mineral nutrition in TAR livestock (LPS/2010/028)

The aim of this project was to evaluate the impact of mineral deficiencies on Tibetan livestock production, assess the production responses to mineral supplementation and assist in the development of a sustainable mineral supplement industry in TAR. The long-term aim was to demonstrate and quantify the economic value of mineral supplementation in livestock production systems in TAR (Waldron and Brown 2010).

By 2010 DFAT was aware of the importance of both the findings from ACIAR-funded baseline mineral surveys and the success of ACIAR crop–livestock investments. As a consequence, DFAT funded research to address mineral nutrition deficiencies in TAR livestock (LPS/2010/028).

Livestock mineral supplementation is known to have the potential to boost livestock production including milk, meat and reproduction. Mineral supplementation through livestock products ('bio-fortification') has the potential to address mineral deficiencies in the Tibetan people. This is particularly the case for iodine and selenium deficiencies, which are known to cause growth defects such as goitre and Kashin-Beck disease, presenting with joint pain and stunted growth; and hypothyroid cretinism, presenting with severely stunted physical and often mental growth (Spiegel and Costa 2010).

As part of this project the township of Duopozhang in the crop–livestock county of Naidong was selected for a livestock mineral supplementation block trial. A mineral block factory was developed in 2012 and 2013 at TAAAS, Lhasa, with CGFD funding. In 2014 TAAAS commenced 'rollout' of mineral block project science. The effectiveness of mineral blocks is yet to be established. Consequently, the economic impact assessment (see Chapter 6) takes a conservative approach to evaluating benefits from this project.

5 Impact pathway analysis

Impact pathway

Consistent with the *Guidelines for assessing the impacts of ACIAR's research activities* (Davis et al. 2008) and Douthwaite et al. (2007), an impact pathway was developed and ratified with TAAAS, TARI and TLRI during fieldwork in TAR. The pathway is linear, and research outputs are produced, developed, extended and adopted to reflect the traditional 'command and control' approach to innovation used in Chinese agricultural systems. Feedback loops do not exist between farmers and researchers but do exist between funders and researchers, and between extensionists and researchers. The final impact pathway incorporating insight from fieldwork is shown in Figure 5.1.

Figure 5.1 shows the further development of ACIAR project outputs by next users TARI and TLRI; the importance of project champions who communicated project successes to TAAAS, PAO and CGFD; and the subsequent substantial funding received from these agencies that allowed for a comprehensive extension program and the widespread adoption of research outputs by crop–livestock zone farmers.

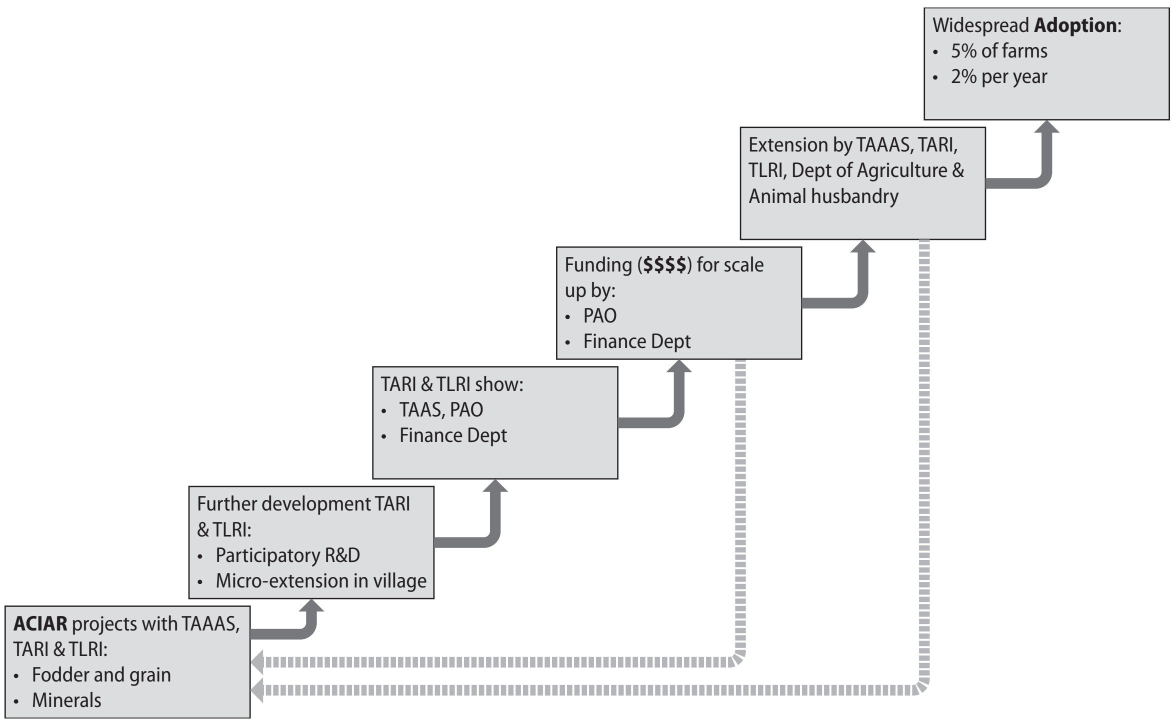

Figure 5.1 Impact pathway

Output, outcome and impact mapping

ACIAR research was completed in TAR at a time of unprecedented change. TAR is China's poorest province and the Chinese Government is addressing Tibetan poverty with a multi-billion-dollar program of infrastructure and other economic initiatives. As a consequence, TAR is rapidly moving from a traditional agrarian society to one with a modernising agricultural sector and a rapidly growing urban population. Impact mapping is therefore needed to allow consideration of the broader context in which the ACIAR projects were set.

ACIAR impact mapping teases out the important distinctions between project outputs, adoption, outcomes and intermediate impacts, and final impacts. A draft impact map was finalised with both Australian project researchers and TAAAS, TARI and TLRI staff in TAR (Figure 5.2).

TAAAS and Institute staff associated with the crop–dairy projects succinctly describe the pathway as shown in Figure 5.3.

The concept of 'happiness' includes economic benefits that are non-monetary such as more milk products to eat, more robust communities and environmental gains.

Adoption strategies employed

ACIAR fodder, dairy and mineral nutrition experiments associated with IAS projects were established at field stations in Shannan and Shigatse (see Figure 4.2). These field stations became the major points where Australian project scientists and local scientists and extension staff could interact and engage local farmers, and where local farmers could participate in hands-on training and be introduced to project technologies.

A multi-adoption pathway was employed to communicate project outputs and secure adoption of project technologies. Pathways employed included communication with farmers via TAAAS extensionists, implementation of TLRI and TARI initiatives (extension and training), and engagement with local Department of Agriculture and Animal Husbandry (DOAAH) extension officers (Colin Brown, University of Queensland, pers. comm.). Project outputs were also used to train PAO-funded extension staff, and double cropping was demonstrated at major PAO-funded field sites (John Wilkins and John Piltz, NSW DPI, pers. comm.; and Wang Jian, PAO, ACIAR visiting paper 2012).

TARI scientists took a lead role in cereal- and fodder-crop extension and training in collaboration with the Australian research teams, and TLRI scientists performed the same function for dairy nutrition. The two institutes tended to work somewhat independently during the early stages of the projects. Data collection was facilitated by an Australian presence. Australian Youth Ambassadors for Development (AYADs) were particularly important when it came to securing complete and accurate field datasets.

Three groups were targeted by Australian researchers for communication and dissemination of the technologies derived from the projects—TAR research scientists, TAR extension staff and, to a lesser extent, local farmers. Techniques employed included:

- participation in field trials and their replication at other sites
- micro-extension at the village level using TAR researchers
- targeting of farm females, who provide most of the farm labour and decision-making
- payments for TAR farmers to attend training courses
- free or subsidised farm inputs to encourage on-farm trials
- production of extension material, briefs and articles in the Tibetan language
- production of train-the-trainer and farmer-training materials in the Tibetan language
- production of an economic model to demonstrate the complex interplay between cropping options, food and fodder supply, milk yield and net cash gain
- communication of project results using TAR radio
- field days at project sites that included farmers and policymakers
- recruitment of leading farmers, who extend findings to their village peers
- scientific workshops and publication of papers in journals.

OUTPUTS

Technologies
- Fodder without jeopardising grain production
- Simple dairy nutrition practices with the potential to increase milk yield
- A whole-farm economic model for research decision-making
- Mineral nutrition technologies for livestock health

Scientific knowledge
- Cereal and fodder options with supporting data for grain (food) security and additional dairy production
- An annual feed budget for dairy cattle
- Quantification of milk production responses to better nutrition
- Recipes for mineral nutrition blocks

Capacity
- Crop and animal scientists trained
- Rote learning giving way to agricultural systems thinking
- International networks developed to encourage continuous learning
- Research infrastructure constructed
- Skills applied to other research projects

Policy knowledge
- Data to support investment in relay cropping (lower altitudes) and dedicated fodder cropping (higher altitudes)
- Data to support continuation of a policy of rangeland destocking and grazing permits
- Data to inform future RD&E priorities

ADOPTION

Commercialisation
- PAO invested in promoting double cropping
- TAAAS provided funding for fodder production in Duopozhang and Bailang
- Impetus to establish a scientifically sound mineral supplement industry, with funding provided by CGFD

Communication
- Scientists communicating results through participatory approaches and village micro-extension staff training
- TAAAS, TARI, TLRI, DAAH and PAO extension to farmers
- Integration of minerals research outputs into other RD&E activities

Capacity building
- Skills developed in ACIAR projects applied to other TAAAS RD&E activities (e.g. design of new cereal chop lengths for sheep and yaks)
- Farmers able to double crop, produce silage/hay, understand feed budgets and improve dairy cow nutrition

Regulation
- Policy evidence and options to support the ongoing destocking of the rangelands and regulatory controls on rangeland grazing

OUTCOMES AND INTERMEDIATE IMPACTS

Changes in farm practice—double cropping and nutrition-based dairy feeding

Demand
- Increased demand for labour—fodder crop production (e.g. sow, harvest) and livestock (straw chop, livestock water and concentrates)
- Increased demand for fodder crop seeds, fertiliser and mineral blocks for cattle

Supply
- No change in grain supply
- Improved supply of fodder
- Increased supply of milk, cheese, yoghurt and butter
- Additional dairy cattle—calves born and cows surviving due to better nutrition

Environmental
- Potential for a reduction in overgrazing of rangelands
- Negation of the need to expand cropping onto marginal lands
- Improvement in the utilisation and recycling of straw
- Additional nitrogen fixed in crop soils by the legume vetch
- Changes in demand for water on crops

Social
- Improved farmer income (due to poverty alleviation, specialisation and transition to commercial farming)
- Improved community health (dairy, mineral)
- Ethnic traditions maintained (e.g. butter tea)
- Greater trust/cooperation between farmers and officials

FINAL IMPACTS

Economic
- Further increase in food security via improved grain-growing techniques
- More-healthy milk products to eat (e.g. butter, yoghurt)
- More milk products to swap
- Increased household income from milk product sales

Environmental
- Potential for more-robust rangeland ecosystems in the future
- More-fertile cropping soils
- Sustainable use of water on crops

Social
- More work for women (e.g. crops, fodder, stock water, milking) but more income for education and consumer durables
- Ethnic traditions maintained
- Social cohesion
- Resilient communities
- Economic engagement
- Stronger research institutions

Figure 5.2 Impact map for the TAR crop–livestock projects

Figure 5.3 Succinct expression of IAS project impact

John Wilkins and John Piltz (NSW DPI, pers. comm.) conclude that adoption strategies that work in other parts of China will not work in TAR. Chinese people in other parts of the country are entrepreneurial, whereas TAR residents are somewhat fatalistic. For older TAR residents simple survival is the primary concern. Nevertheless, young TAR people are changing and may be more responsive to market opportunities provided by economic development, including producing and selling surplus milk. TAR residents now have access to mobile phones and satellite TV and are exposed to modern consumerism. A large number of them wish to exit farming and gain entry into other occupations (David Coventry, The University of Adelaide, pers. comm.). TAR people are torn between maintaining traditional cultural practices and wanting economic opportunities for their children. This internal conflict affects their interest in, and adoption of, new farming technologies.

Extension sessions held off-farm were reported to be somewhat intimidating for TAR farmers, whereas demonstrations held on-farm and inclusive of farm females were reported to be far more useful. Not all extension sessions associated with the ACIAR projects were effective.

Noting difficulties in the rollout of adoption strategies is reason to be somewhat cautious about the adoption rates proposed by TAAAS scientists. The suggested current adoption rate of 10% plus an additional 3%–5% take-up annually is halved in the economic evaluation, and total adoption is capped at 40% of crop–livestock zone smallholders.

Linkages between researchers and next users

Impact pathway analysis draws a distinction between adoption of research outputs by next versus final users of the research. Next users have responsibility for further development and extension of the research outputs, whereas adoption by final users leads to agricultural practice change (D. Templeton, pers. comm. as cited in Palis et al. 2013). In this instance next users include TAAAS (TARI and TLRI), DAAH and PAO.

Participation in, and adoption of, ACIAR research project outputs by TAAAS and its two specialised institutes TARI and TLRI has been comprehensive and enthusiastic. The TAR research agencies have been willing participants who have further developed research outputs, especially relating to double cropping, simple dairy nutrition and mineral supplementation, outside the ACIAR projects.

Adoption achieved (final users)

Agricultural practice change in the TAR crop–livestock zone as a result of IAS projects includes both current impacts and a comment on forecast future changes. It includes adoption of fodder crops, conservation farming, simple strategies to improve cow nutrition, fodder conservation and mineral supplementation.

ACIAR research team challenges in achieving adoption included movement restrictions, language difficulties, poor road access and changes in staff, including the LPS/2006/119 project leader. Nevertheless, significant final-user practice change has been achieved (Poppi et al. 2011).

Relay crops and dedicated fodder crops

Prior to commencement of the ACIAR projects there were no relay crops in the lower altitude areas of the crop–livestock zone, and dedicated fodder crops were not encouraged in either the lower or higher altitude areas. Oats was classified as a weed. Farm policy was focused on food security, which in practical terms meant growing enough grain to feed the TAR population.

Grain security has now been achieved in TAR, and since commencement of the ACIAR projects in 2004 the policy focus has shifted to 'fodder security'. In the lower altitude areas relay cropping of vetch, a CIM/2002/093 project recommendation, has become a popular farm enterprise. Adoption has been encouraged by the low labour requirements, training funded by PAO and the distribution of free vetch seed. 'Farmers are adopting this technique because it is simple and maintains the high cereal yield that households require for food security while providing 3–4 t/ha of quality vetch hay before winter' (Poppi et al. 2011).

For food security and ongoing work to improve cereal yields, farmers in both higher and lower altitude parts of the crop–livestock zone are growing dedicated fodder crops. Typically, this involves sacrificing a small area of cereal land for oats or triticale production. Poppi et al. (2011) were able to observe a large-scale oat-for-fodder production project that stemmed from ACIAR research in the township of Qu-mei, near the higher altitude area Shigatse in Xigaze Prefecture.

The production of relay and dedicated fodder crops has improved the quality and quantity of hay available to livestock, especially dairy cattle, over the winter and spring months. Dedicated fodder crops have also allowed the emergence of specialised fodder growing businesses, which service dairy expansion and the emergence of a commercial dairy sector, and also trade fodder for food such as locally grown barley and imported rice. The ACIAR projects have allowed smallholder farms to enter the market economy.

Wang Jian (ACIAR visiting paper 2012) noted that PAO had supported the planting of 45,000 mu (3,000 ha) of fodder crop based on ACIAR's recommendations, and that 10% of all crop–livestock zone farms were now growing fodder crops.

Conservation farming including zero tillage

ACIAR IAS project design included incorporation of zero tillage into research experiments. In 2014 zero tillage had only been used on the TAAAS research farms. Zero-tillage equipment was brought to TAR in 2005 as part of an FAO Technical Cooperation project. However, the absence of an on-ground researcher to demonstrate and train farmers in its use has resulted in limited application. At present, adoption of zero-tillage systems is beyond smallholder agronomic skill sets. Hand sowing of vetch is as close as the crop–livestock zone currently gets to zero tillage (David Coventry, The University of Adelaide, pers. comm.). Broadcast sowing of vetch is a zero-till solution offering attractive labour savings and soil quality protection (Poppi et al. 2011).

Simple strategies for improved dairy cow nutrition

Simple change practices for improved dairy cow nutrition recommended by the ACIAR projects (LPS/2002/104 and LPS/2006/119) have been adopted. Smaller cereal straw chop length was shown to increase cow intake and this was seen to be used by smallholders during farm visits. Optimal forage concentrate ratio was determined in two cow genotypes, with the information able to be used in new feed budgets and the CAEG Tibet economic model. Households have taken on board the recommendation to increase the water supply available to tethered cows, and adoption has shown marked improvements in milk production and calf and cow survival (Dr Nyima Tsamyu, TLRI, pers. comm.).

Poppi et al. (2011) observed these changes firsthand during farm visits to the township of Ba Zha, Shigatse, Xigaze Prefecture, in 2010 (a higher altitude area), and Alford and Clarke were assured of the same adoption and benefit profile by villagers in Duopozhang, Shannan Prefecture, in 2014 (a lower altitude area).

Initial concerns about reluctance to adopt recommendations relating to increased drinking water supply because it would make the resultant dung too wet and diluted for collection and use as household fuel proved to be unfounded. Poorer quality dung is more than offset by the increased value of the milk produced (Dr Nyima Tsamyu, TLRI,).

Adoption of simple strategies for improved dairy cow nutrition will be facilitated by the ongoing rollout of PAO's dairy cow artificial insemination (AI) program. Some 60,000 dairy cows and 30,000 households in the crop–livestock zone benefit from this program each year (Wang Jian, PAO, ACIAR visiting paper 2012). It is reasonable to expect simple change practice recommendations (chop length, increased water supply and forage concentrate ratios) to be rolled out to the same households and at the same time.

Jersey genetics for dairy production

An almost incidental recommendation arising from project LPS/2002/104 was PAO's AI program switch from Holstein and Simmental dairy genetics to Jersey genetics, especially in the higher altitude areas. High butterfat content is preferred by Tibetan smallholders and low feed intake is a necessity. Jerseys outperform Holstein and Simmental in both these attributes. This recommendation, made by Wilkins and Piltz (2008), has subsequently been adopted and has proved successful in TAR.

Fodder conservation and annual feed budgets

At the commencement of the ACIAR projects there was universal smallholder naivety about the value of various feed types and the importance of supplementing low-nutrient straw with high-protein fodder. The ACIAR milk production (LPS/2002/104) and integration (LPS/2006/119) projects introduced technologies for silage making, annual feed budgeting and haymaking that includes vetch, oats and triticale.

The introduction of silage has only occurred in a limited way. TAAAS continues to demonstrate the technique at their research farm at Lhasa, and some farms, including a limited number of smallholders, have adopted silage making. The problem with silage is that it is labour intensive at harvest when labour is in short supply (David Coventry, The University of Adelaide, pers. comm.). Silage may be more relevant to the crop–livestock zone in the future when larger scale dairies emerge or if opportunities to breed livestock in the pastoral zone and finish them in crop–livestock areas can be developed.

John Wilkins and John Piltz (NSW DPI, pers. comm.) suggested that finishing rangeland-bred livestock in the crop–livestock zone would be a worthwhile ACIAR project. The project idea was further supported by TLRI during field investigations; that is, researching the merits of further increasing fodder production, fattening rangeland-bred livestock in the crop–livestock zone, and reforming the livestock-for-meat production system with younger slaughter stock rather than consumption of poor-eating 8-year-old yaks.

Annual feed budgeting was taught to TLRI scientists as part of the ACIAR projects, and the scientists have used the technique in making recommendations to smallholders. At present smallholders are not preparing their own annual feed budgets using ACIAR project techniques.

Of some considerable success is additional haymaking using vetch, oats and cereal straw in line with ACIAR project recommendations. The crop–livestock zone has a very dry harvest and is an easy place to make hay. Haymaking is also consistent with traditional smallholder farm practice.

Extension of fodder conservation and feed budgeting techniques has been recognised as a future RD&E priority in the crop–livestock zone by PAO (Wang Jian, PAO, ACIAR visiting paper 2012). This should assist with the long-term and ongoing rollout of fodder conservation and annual feed budget recommendations.

Mineral supplements

Mineral supplementation trials using research knowledge developed by ACIAR IAS project LPS/2010/028 were underway in Duopozhang, Shannan Prefecture, in August and September 2014. TAAAS plans to expand these trials into other areas and develop a commercial mineral block manufacturing business. A manufacturing factory has already been built and is producing mineral blocks on a trial basis. It plans full-scale production using blocks prepared using ACIAR project recipes.

It is difficult to establish the impact of selenium increases on livestock performance and profitability (Colin Brown, University of Queensland, pers. comm.). There is some scepticism in agencies such as PAO as to the worth of mineral supplements, and John Wilkins and John Piltz (NSW DPI, pers. comm.) note that production responses certainly need clear demonstration to justify widespread recommendations for supplementation. The economic benefits associated with mineral supplementation have been treated conservatively in this IAS.

Current and future adoption

There was widespread consensus in TAR research institutions and PAO regarding the level of adoption achieved by ACIAR research outputs. The consensus was that 10% of crop–livestock zone smallholder farms in 2014 had adopted research outputs and that the worth of research findings would mean that adoption would increase at between 3% and 5% per year for the foreseeable future (Madame Se Zhu, Vice Director TLRI, pers. comm.; and Wang Jian, Deputy Director PAO, pers. comm.).

However, a more conservative approach has been adopted in the economic evaluation in this IAS, where a base adoption rate of 5% in 2014 with a 2% growth factor capped at 40% of total smallholders has been assumed. A more conservative approach to adoption was selected after consideration of extension difficulties, as reported in Section 5.3.

Drivers of adoption

The preceding pathway analysis shows that the drivers of adoption of project outputs were:

1. TARI and TLRI scientists, who developed additional research and extension capacity through the ACIAR projects; established links between the ACIAR research, PAO and CGFD; and completed extension with individual smallholders
2. sound scientific data created by the ACIAR projects, which clearly showed the benefits of the new technologies (e.g. relay cropping, dedicated fodder crops, simple livestock nutrition, switching to Jersey genetics, mineral nutrition) and gave PAO and CGFD the confidence to invest in their rollout
3. PAO and CGFD resources, including payments to farmers to attend training and free fodder seed to encourage planting
4. supporting investment by PAO and CGFD in AI, fodder stores, and roads and bridges to transport product to market.

The first two of these factors can reasonably be accounted for by sound project design. Factors 3 and 4 are relationship dependent (e.g. through contacts with funding authorities) and somewhat serendipitous—TAR is benefiting from a major Central Government investment program.

Lessons learnt

Impact pathway analysis has provided the following insights relevant to future project design:

1. Impact pathway maps completed prior to project rollout did not predict the large-scale and rapid investment response of PAO.
2. Real-time management of the adoption pathway may be important. The impact pathway may need to be modified during the project to take account of new opportunities.
3. Human relationships between Australian researchers and next users of research outputs are essential and were developed, at least in part, through good fortune.
4. In future more effort should be directed toward planning human networks; for example, routine contact with multiple senior officials in TAAAS, PAO and potentially even CGFD.
5. The projects were well targeted, focusing on the culturally significant dairy industry, and this in turn contributed to favourable rates of adoption.
6. Adoption was also facilitated by low-/no-cost production inputs and productivity improvements that did not require large amounts of scarce household labour.
7. Extension is likely to have been facilitated by a single 'in charge' agency and would have benefited from a formal coordination plan, AYADs and delivery on-farm by ethnic Tibetans.
8. Extension messages should target farm females, who supply much of the farm's labour and are active in farm decision-making.
9. An Australian presence in-country and on site helped to ensure steady progress toward project goals.

Pathway analysis informs science, capacity, economic, social and environmental impact assessment.

6 Impact assessment

Consistent with ACIAR guidelines, the impact assessment includes an analysis of scientific impacts and capacity building along with quantitative analysis of economic impacts and a description of social and environmental changes.

Impact assessment is prefaced with a clear statement of the counterfactual.

Articulation of the counterfactual

In the absence of ACIAR investment in the projects, TARI and TLRI scientists would not have received additional training in plant and animal science, and both institutes' science infrastructure would not have been augmented to the extent that has been achieved. The foundations of a science culture based in agricultural systems thinking would have been delayed, possibly by as much as 5 years. The science culture developed in TARI and LTRI has been essential for developing and extending ACIAR research outputs and has been applied to other TAAAS projects (e.g. selenium fortification of grains, trialling of dwarf grain varieties, and sheep and yak nutrition research).

In the absence of the ACIAR projects there would also have been a delay in the generation of data to support the adoption of relay sowing of vetch, dedicated fodder oat crops and simple dairy nutrition. The FAO and EU projects that ran at the same time as the ACIAR research were general in nature, and did not produce convincing data nor have the same 'champions' who successfully communicated outputs to next users. The adoption of relay cropping would have been delayed in the lower altitude areas of the crop–livestock zone for an estimated 5 years in the absence of ACIAR's investment. Land would not have been set aside for dedicated fodder crops in higher altitude areas and dairy nutrition would not have received attention as a priority research issue. The prevailing Tibetan attitude noted by John Wilkins and John Piltz prior to project commencement, that a 'bucket of straw was as good as a bucket of grain' in terms of dairy nutrition, would have continued to prevail. 'Prior to 2004 we didn't realise fodder was important. We only focused on grain yield. Through the ACIAR projects we learned that fodder was important for farmer income and the environment. Grassland overgrazing and erosion is a big issue in Tibet' (Jin Tao, Associate Professor, TARI, pers. comm.).

Under the counterfactual, TAAAS and PAO would have rigorously pursued solutions to dairy underperformance based on genetic improvement using AI. The focus of dairy genetics would have continued to be on Holsteins that yield high milk but low butterfat and which are poorly suited to higher altitude TAR grazing. In the medium term these large-framed, high-input cows would have continued to underproduce in Tibetan conditions. 'In the absence of vastly improved feeding systems the continuation of the introduction of 'improved' genotypes (usually Holstein) would have exacerbated the dairy system underperformance problem' (Poppi et al. 2011, page 4). 'We now understand that nutrition is a major problem for cattle in the crop–livestock zone of Tibet; they stop breeding and when in very poor condition they give little milk' (Wang Jian, PAO, pers. comm.).

Persuasive datasets created by the ACIAR projects provided PAO with a successful 'hook' with which to interest crop–livestock zone smallholders. PAO was able to demonstrate improved milk yields with little additional labour and few purchased inputs. Access to this ACIAR-created 'hook' allowed PAO to engage smallholder farmers and 'hang' other social improvement initiatives off a relatively simple set of farm management changes. Under the counterfactual, broader social and environmental benefits, largely attributable to the substantial investment made by PAO, would have been delayed. Consequently, the outcome is likely to have been a 5-year stagnation in relation to progress with milk yields, calves born and adult cows surviving, and in time possible disillusionment by smallholders with TAR researcher recommendations.

Scientific impacts

Scientific impacts include facilities developed and impacts realised as a result of project investment. Facilities developed by ACIAR IAS projects were an animal house for testing dairy cattle response to improved nutrition; an agronomy laboratory for testing the nutritional qualities of grain and fodder; and a minerals analysis laboratory to assist with a range of chemical analyses and field studies that address mineral deficiency. Details are provided in Table 6.1.

Scientific impacts

Scientific impacts realised from the ACIAR IAS projects include:

- cereal and fodder production systems with supporting data for the improvement of grain security and additional dairy production in TAR; forage production systems now provide a means of improving the quality of livestock diets
- an annual feed budget for two genotypes of dairy cattle; quantification of milk production responses to better nutrition and by stage of lactation
- an understanding of the impact of mineral deficiencies on grain, livestock and human health; recipes for mineral nutrition supplementation blocks to address livestock deficiencies

Table 6.1 Scientific facilities developed

Facility	Relevance to TAR development goals
Animal house	• Purpose: to test dairy cow response to improved nutrition • Constructed at TLRI's research facility in Lhasa as part of project LPS/2002/104 and also used for project LPS/2006/119 experiments • Includes laboratories for basic feed quality analysis and equipment for weighing dairy cattle • TLRI scientists were trained in its use by Australian researchers. In turn, TLRI scientists have passed their knowledge on to more-junior colleagues • Is the only facility of its type in TAR • Is an essential contributor to livestock research objectives. • Was used in 2014 for sheep and yak nutrition research including establishment of the ideal straw chop length for sheep and yak/yak crosses; the ideal chop length differs from that of dairy cattle
Agronomy laboratory	• Purpose: testing of fodder and grain nutritional qualities • Constructed at TARI's research facility in Lhasa as part of project CIM/2002/094 and also used for project LPS/2006/119 experiments • TARI scientists trained by Australian researchers have continued to employ skills they developed and have passed them on to their colleagues • Includes equipment for sowing and harvesting crop trials including seeders and threshers; it is also equipped with basic analysis equipment including ovens for the preparation of fodder and grain samples
Minerals analysis laboratory	• Purpose: to provide analytic equipment to support ongoing mineral deficiency research in TAR • Was established as part of project LPS/2005/129 and has since also been used for project LPS/2010/028

- predictions of whole-farm production as a result of adoption of project outputs; tools for predicting whole-farm production developed as part of the projects include the CAEG Tibet economic model
- scientific literature including book chapters, publications in refereed journals, thesis studies, contributions to national conferences (TAR and Australia) and international conferences—see References for a list of publications produced by the IAS projects.

Conclusions on scientific impact success

The scientific impacts of the IAS projects are comprehensive and consistent with the aims expressed in the project proposal documents. Facilities have been supported and the capacity of TAR staff enhanced. There is evidence of facilities being used for other scientifically worthwhile projects and scientists passing skills onto less-experienced members of staff. These changes support the shift of agricultural research capacity in the region towards best practice.

Capacity-building impacts

Capacity building is an integral part of development assistance. It seeks to build the understanding, skills and knowledge base of individuals and institutions in developing countries (Gordon and Chadwick 2007).

Capacity-building activities contribute to improved economic, environmental and social outcomes through four main pathways (Davis et al. 2008):

- Individual human capital raises the productivity and hence the earning capacity of the individual, reflected in higher lifetime income.
- The efficiency of the organisation captures part of the returns from individual improvement in productivity and, due to the echo effect, improves the productivity of other workers via complementarity.
- Innovation in the organisation introduces new and better ways of doing things, and new products and services are developed as the culture and mindset changes.
- The effectiveness of the organisation within the policy environment improves targeting to areas of need, attracting more resources and engaging more effectively on policy, due to networking and enhanced perception of the views of the organisation, as well as its competency.

Each of the IAS projects has a strong capacity-building focus, and Australian and TAR researchers identified capacity building as the single most important and lasting impact created by the ACIAR projects. Consequently, analysis of the capacity-building impacts includes the role of the individuals who benefited from capacity creation, the specific capabilities developed by ACIAR, and their application to ACIAR and other development activities (see Table 6.2).

Capacity-building techniques employed

Techniques employed during the projects to build TAR research capacity included:

- scholarships for a Masters-level qualification in Australia (3 TAR students and 1 Australian student)
- research standards training in Australia (6 TAR students)
- Australian technical tours to view fodder crops and dairy nutrition in the NSW Riverina (6 TAR students)
- techniques to encourage collaboration between research and extension staff (2 workshops held in TAR)
- workshops on Australian extension systems and ways to improve TAR extension (3 workshops held in TAR)
- workshops on participatory approaches and understanding change limitations (2 workshops held in TAR)
- evaluation and impact assessment training (4 workshops given by Debbie Templeton, ACIAR, in TAR in 2012 plus 1 half-day overview workshop on impact assessment given by Andrew Alford and Michael Clarke, September 2014)
- farm economics training, including in the use of the CAEG Tibet economic model (4 research scientists

trained in TAR and 4 TAR students provided with follow-up training in Australia)

- statistics training in TAR and introductory training in the CAEG Tibet economic model (20 research scientists trained)
- preparation of scientific papers and presentation at international conferences—skills that help ensure the quality of Tibetan agricultural research (see References)
- on-the-job training in TAR–English-language skills, surveys, data collection and collation (training provided to 8 TAR scientists).

Science skills developed by Tibetan professionals

Science, project and management skills developed by key TAR professionals are summarised in Table 6.2.

Table 6.2 Capacities developed through ACIAR projects and their application in TAR and to IAS / other projects

Title, Institution	Role	Specific capacities developed	Application of developed capacities
Research Leader	• Decision-maker on whether development project proposals will be approved • Allocates local resources to development projects • Makes the case to funding agencies for development project 'scale up' and extension • Close working relationship with Senior Development Officials	• Design of effective research institutions • Research management in agriculture • Agricultural systems thinking • Encouraging others to develop hypotheses and design experiments • International benchmarks in crop science • Design and management of animal house studies • Basic training in social science • Scientific paper writing	• Restructured TAAAS along Australian CRC lines with six issue-focused research institutes • Started the process of shifting research scientist thinking from rote learning to analysis and problem solving in an agricultural system • Supported ACIAR projects including capacity building for TARI & TLRI staff • Provided impetus for focus on fodder and dairy nutrition not just genetics and AI • Passed on skills developed with ACIAR to other staff members • Currently responsible for barley—TAR's most important crop
Senior Development Official	• Allocates the substantial Tibet poverty alleviation budget ($A billions) • Has capacity to be a project patron or terminate a project • Can marshal resources and political goodwill	• Understanding of the importance of dairy nutrition • Understanding that large Holstein and Simmental cows are not best suited for areas that have little fodder and require high-butterfat milk	• Refocused substantial resources away from Holstein and Simmental genetics to fodder production, simple nutrition measures and support for Jerseys in higher altitude areas

continued

Table 6.2 (cont'd) Capacities developed through ACIAR projects and their application in TAR and to IAS / other projects

Title, Institution	Role	Specific capacities developed	Application of developed capacities
Senior Researcher, TARI	• Made a strong case to support the further development and 'rollout' of relay cropping using vetch (in lower altitudes) and oats/ triticale (in higher altitudes)	• Agricultural systems analysis and project design • Developing hypotheses, experiment design • Crop modelling and agronomic trials • Use of laboratory methods to assess the nutritive value of grains and feeds • English-language skills • Plant growth models and longer-term work plans • Soil classification and sampling • Basic training in social science • Scientific papers	• Field and extension work completed was responsible for further development of ACIAR project outputs and their suitability for widespread adoption • Used experimental and agronomic trial design skills to develop new program of work around bio-fortification of barley and use of more-productive dwarf grain varieties • Published papers in international journals with Australian scientists • Passed on ACIAR-learned skills to postdoctorate students working in the TARI team
Senior Researcher, TLRI	• Works closely with Research Leader to support the further rollout of dairy nutrition recommendations	• Agricultural systems analysis and project design • Experiment design • Animal trial design • Use of animal house to assess feed requirements and nutritive value of grains and feeds • Laboratory analysis techniques, e.g. pepsin/ cellulase digestibility • Data collection, record keeping and timely data entry • Statistical analysis techniques	• Skills have allowed leadership position in the Nutrition Research Group at TLRI • Animal house and extension work completed was responsible for further development of ACIAR project outputs and their suitability for widespread adoption • Used experimental and animal house skills to develop new program of work around yak nutrition in the pastoral zone • Passed on ACIAR-learned skills to other team members

continued

Table 6.2 (cont'd) Capacities developed through ACIAR projects and their application in TAR and to IAS / other projects

Title, Institution	Role	Specific capacities developed	Application of developed capacities
Research Scientist, TLRI	• Livestock research	• Grazing assessment • Animal house use • Nutrition laboratory training • Developing hypotheses and designing experiments • Survey design and execution • Data collection from agronomic and animal nutrition trials • Simple statistical analysis techniques • Use of CAEG Tibet whole-farm economic model	• Collection of quality data provided confidence in the results of ACIAR project work in dairy nutrition • Skills developed in ACIAR dairy nutrition now applied to ACIAR minerals projects
Research Scientist, TARI	• Crop research	• Skills developed through John Allwright Fellowship include plant health, biosecurity design, entomology, economic models, farmer surveys, extension • Developing hypotheses and designing experiments • Research methodology and writing • Spoken and written English-language skills including training in Australia, Beijing • Simple plant growth models and longer-term work plans • Soils classification and sampling • Soil nutrition • Data collection: multiple random samples, sampling consistency, taking range of measures from every plot • Record keeping, timely data entry • Weed control in plots	• Used research methodology and writing skills to contribute to ACIAR and other projects (e.g. grain trials, fodder trials, mineral deficiency investigations and bio-fortification work) • Skills developed through a Masters degree led to improvements in TAR biosecurity systems • Skills developed in extension were directly applied to a new role at the TAAAS Farmer Training Centre • Provided leadership to other projects including work being completed by the International Centre for Integrated Mountain Development

continued

Table 6.2 (cont'd) Capacities developed through ACIAR projects and their application in TAR and to IAS / other projects

Title, Institution	Role	Specific capacities developed	Application of developed capacities
Research Scientists, TLRI	• Livestock research	• Skills acquired through John Allwright Fellowships include developing hypotheses and designing experiments, research methodology and writing, a deeper knowledge of animal and forage production, laboratory analysis related to feed quality and animal house experimentation • Improved spoken and written English-language skills	• Have further strengthened the capacity for animal production and nutrition research at TLRI

Science skills developed by Australian professionals

Scientists:

- Masters-level qualification in Australia focusing on TAR research
- AYADs who learned agricultural development skills in TAR and also contributed technical knowledge to TAR scientists.

Conclusions on capacity-building success

In 2003 TAR had extremely limited scientific research capacity; in 2014 TAAAS is better resourced and has capacity to complete both plant and livestock research. TAAAS Australian-trained scientists are capable research professionals who have remained with the Academy.

This study found that the ACIAR project investment in capacity building has been effective, with evidence of sustained impacts—TAAAS has a number of highly skilled research scientists who are in the process of passing their knowledge on to their younger peers. Regardless of changes to the current agricultural production system in TAR, research skills developed with the assistance of ACIAR will remain relevant.

Economic impact

Impact pathway analysis has shown that final impacts associated with ACIAR projects have or are likely to include:

- more work for women but more income for education and consumer durables
- maintenance of ethnic traditions
- resilient communities and social cohesion
- economic engagement by rural smallholders
- stronger research institutions
- the potential for more-robust rangeland ecosystems
- fertile cropping soils
- a further increase in TAR food security via improved grain growing techniques
- additional calves raised and cow deaths avoided
- more-healthy milk products to eat (e.g. butter, yoghurt, cheese and fresh milk)
- more milk and milk products to swap
- increased household income from milk and milk product sales.

Each of these impacts has an economic dimension. This economic impact assessment concentrates on quantification of a subset of the most important final impacts, which are:

- milk production increase
- additional calves raised and cow deaths avoided.

On-farm a milk production increase (from improved nutrition) and reduced livestock mortality leads to a reduction in the cost of milk production from the same-sized dairy herd.

On-farm impact

To determine the reduction in the unit cost of milk production (Y/kg) and the overall supply shift (*K-shift)* resulting from adoption of ACIAR research outputs, partial budgets were developed for both lower and higher altitude farms (Table 6.3 and Table 6.4). Data and assumptions used to prepare these budgets are provided in the balance of this report section.

Adoption of ACIAR research outputs resulted in a significant increase in milk production, from a base of 5 kg/cow/day to 10 kg/cow/day. The assumed increase is conservative. TLRI staff and smallholders report larger gains in production, and milk yield remains below genetic potential.

Milk is a valuable commodity in TAR, with a farm-gate price of Y9.60/kg ($A1.92/kg) and a retail price in Lhasa of Y24.00/kg ($A4.80). Fresh milk sourced from smallholders is strongly preferred to imported ultra-high temperature (UHT) milk.

Adoption of ACIAR research outputs results in an improvement in dairy cow nutrition, with a reduction in the incidence of cows failing to conceive or produce a viable calf. TLRI advice is that a typical smallholder herd will improve its rate of reproduction by 50% following introduction of ACIAR research recommendations. At the same time, adult cow death rates will be reduced by an average of one cow every 2 years in smaller lower altitude herds and one cow every year in larger higher altitude herds. As with increased milk production, decreased mortality reduces dairy production costs and boosts farm income.

The economic cost of lost calves and adult cows before the introduction of ACIAR research outputs was based on a 3-month-old calf value of Y1,250 ($A250) and an adult cow value of Y10,000 ($A2,000). These data were sourced from TLRI (Dr Nyima Tsamyu, pers. comm.).

A replacement cow cost allowance, somewhat similar to an allowance for capital depreciation, has been made for herds both before and after the introduction of ACIAR research outputs. Cost is based on a 12-year productive life for Tibetan dairy cattle.

Relay cropping of vetch and dedicated fodder crops of oats provide the foundation for improved dairy cow nutrition. To encourage adoption of ACIAR research outputs in 2014, PAO gave away fodder crop seed, discounted fertiliser and did not charge for irrigation water. The partial farm budget analysis uses the full economic cost of these inputs. Seed cost included the cost of transporting it from other parts of China, and a similar approach was used to estimate fertiliser values.

Irrigation water price was estimated at Y20/mu ($60/ha) for the higher altitude model following discussions with TARI research staff. Tractor costs were also estimated with TARI and are based on current contract rates. Irrigation water, fertiliser and the use of tractors to prepare the ground for sowing are not required to grow vetch on lower altitude farms.

Labour for fodder production (e.g. planting and harvesting) and additional dairy-related tasks (e.g. straw chopping, additional water provision and forage concentrate supply) was costed at the full casual rate for hired agricultural labour. The value of agricultural labour has increased significantly since the projects began; casual farm labour cost Y50/day ($A10/day) in 2014.

Adoption of research outputs requires considerable additional labour—0.2 full-time equivalents (FTE) in lower altitude areas and 0.5 FTE in higher altitudes areas. TARI and TLRI staff are confident that additional income earned on-farm from adopting ACIAR research outputs is greater than the opportunity cost (i.e. off-farm employment).

Tables 6.3 and 6.4 show additional income (milk sales) and input costs (fodder production and labour) with ACIAR research outputs in place, and additional costs incurred (e.g. cow losses, calf income foregone) in the absence of ACIAR research outputs. The tables also provide a *K-shift* estimate.

Cost of ongoing adoption

Current adoption of ACIAR research outputs is assumed to be 5%, with annual growth of 2% up to a maximum adoption rate of 40%; that is, use of the technology increases each year by 2% for 18 years until it reaches 40%. Ongoing growth in adoption is a 'no-cost' by-product of PAO investments in Tibetan agriculture. PAO has indicated that it will continue to roll out AI and subsidised fodder inputs (e.g. seed and fertiliser where fertiliser is required). ACIAR research outputs (fodder production and simple dairy nutrition) will continue to be communicated via PAO at no, or very low, marginal cost, and will be extended as part of a package of agricultural development initiatives. No additional cost for future extension is made in the economic impact assessment.

Welfare analysis of ACIAR project benefits

The benefits of ACIAR research outputs were estimated using standard welfare (economic surplus) analysis, as described in detail in, for example, Alston et al. (1995). In a static supply and demand model (Figure 6.1) the impact of double cropping and simple dairy nutrition is modelled as a reduction in the unit cost of producing milk ('bc' yuan) at the initial equilibrium level of production, Q_0. The assumption that ACIAR-generated technology results in the same savings in costs at all levels of production gives a downward shift (*K*), from S_0 to S_1, in the supply of milk at the farm level. This results in an increase in farm milk production from Q_0 to Q_1 and a fall in the farm price of milk from P_0 to P_1.

The gains (surpluses) to producers (ΔPS) and consumers (ΔCS) (including Lhasa- and Shigatse-based milk processors) are represented by the areas 'efcd'

Table 6.3 Farm partial budget, 5-head dairy herd—lower altitude

	Without ACIAR research outputs ('old technology')	**With ACIAR research outputs ('new technology')**
Revenue (milk) (Y)	24,000	48,000
Operating costs (Y):		
Replacement cow allowance	4,167	4,167
Cow mortality	5,000	0
Calf income foregone	1,563	0
Vetch seed	0	750
Vetch sowing	0	250
Vetch harvesting	0	750
Dairy labour—additional	0	2,500
Dairy concentrates	0	6,400
Total costs (Y)	**10,729**	**14,817**
Operating profit (Y)	**13,271**	**33,183**
Amount of milk produced (kg)	2,500	5,000
Production cost (Y) per kg	4.29	2.96
Reduction in production cost (Y) per kg (also known as *k*)	1.33	
K-shift [a]	14%	

Sources: Wilkins and Piltz (2008) and consultation with TARI and TLRI staff

[a] Cost saving of Y1.33/kg divided by milk price of Y9.60/kg

and 'abfe', respectively, and described by the equations (Alston et al. 1995):

$$\Delta PS = (K - Z)\, P_0\, Q_0\, (1 + 0.5Z\eta) \quad (1)$$

$$\Delta CS = P_0\, Q_0\, Z\, (1 + 0.5Z\eta) \quad (2)$$

where:

$K = k/P_0$

$Z = K\varepsilon/(\varepsilon + \eta)$

k is the reduction in production cost per kg

ε is the elasticity of supply at the farm level

η is the absolute value of the elasticity of demand at the farm level.

Total industry welfare gains are the sum of the changes in producer and consumer surpluses. The distribution of gains between the two depends critically on relative demand and supply elasticities.

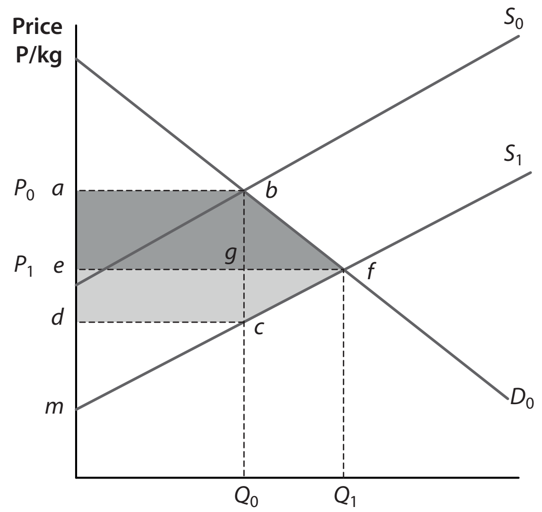

Figure 6.1 Welfare changes from double cropping and dairy nutrition. Source: Montes et al. (2008)

Table 6.4 Farm partial budget, 8-head dairy herd—higher altitude

	Without ACIAR research outputs ('old technology')	With ACIAR research outputs ('new technology')
Revenue (milk) (Y)	54,240	108,480
Operating costs (Y):		
Replacement cow allowance	6,667	6,667
Cow mortality	10,000	0
Calf income foregone	3,531	0
Oats seed	0	840
Tractor cultivation for sowing	0	35
Oats fertiliser	0	370
Oats sowing	0	350
Oats irrigation	0	280
Oats harvesting	0	1,050
Dairy labour—additional	0	5,650
Dairy concentrates	0	14,464
Total costs (Y)	20,198	29,705
Operating profit (Y)	34,042	78,775
Amount of milk produced (kg)	5,650	11,300
Production cost (Y) per kg	3.57	2.63
Reduction in production cost (Y) per kg (also known as *k*)	0.95	
K-shift	10%	

Sources: Wilkins and Piltz (2008) and consultation with TARI and TLRI staff

An estimate of the K-shift

As described above, the *K-shift* for lower altitude farms is 14% and for higher altitude farms is 10%.

Demand and supply parameters

The analysis uses demand and supply elasticities that are based on field observations of dairy production in TAR. Econometric estimates were unavailable. Adoption of ACIAR research outputs is unlikely to have had a large impact on the price of milk (the market is undersupplied). Consequently, a highly elastic demand (–5.0) for milk has been used in the analysis.

Econometric estimates of supply response for livestock are notoriously low, often less than 0.3. The judgement developed after TAR field investigations was that producers have a greater incentive and capacity to increase production once ACIAR research outputs have been made available. Consequently, a supply elasticity of 1.0 has been used in the analysis.

Equilibrium price and quantity

Equations (1) and (2) indicate that welfare effects are significantly influenced by the choice of product price and quantity. Welfare analysis of the type applied here is generally conducted using prices and quantities judged to be those existing when the industry is close to equilibrium prior to introduction of the technology (ACIAR research outputs). The prices and estimates of welfare changes are regarded as being real (rather than nominal) and projected forward over the period of the analysis, disregarding other exogenous impacts on the industry that will likely qualify the actual benefits accruing (Montes et al. 2008).

Another dimension of the choice of equilibrium price is that, in the approach used here, the supply shift *K* is estimated as the change in unit production costs as a proportion of product price, on the assumption that price in equilibrium is equal to the long-run average cost of production (Montes et al. 2008).

Quantity is estimated as the average of lower and higher altitude farm milk production before introduction of the ACIAR research outputs, as shown in Table 6.3 and 6.4.

Q_0 is the quantity of milk produced in the lower altitude region and the higher altitude region by farmers who are targets for the new technology prior to its introduction.

A single model has been prepared for both regions. The quantity of milk produced is estimated as the volume produced by each region's representative farm (see Tables 6.3 and 6.4) multiplied by the number of farms in the region.

Producer and consumer surplus estimates

The relevant parameters needed to derive changes in producer and consumer surplus, along with the changes in producer and consumer surplus realised, are summarised in Table 6.5.

Investment return

Investment return is determined over a 30-year period commencing in the last year of ACIAR investment (2011–12). All benefits and costs are discounted to 2013–14 values using a discount rate of 5%. Relevant data used to develop the investment return are summarised in Table 6.6.

Table 6.7 shows the present value of ACIAR project investments and resultant revenue streams.

Investment returns on IAS projects and ACIAR share of total investment are summarised in Table 6.8.

The total investment of $8.28 million (present value terms) has been estimated to produce gross benefits of $125.01 million (present value terms), providing a net present value of $116.73 million and a benefit:cost ratio of 15:1 (over 30 years using a 5% discount rate). The ACIAR investment has been successful.

Sensitivity analysis

Sensitivity analyses were carried out on two sets of variables and results are reported in Tables 6.9 and 6.10. All sensitivity analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 6.9 presents the sensitivity of the results to the discount rate.

Table 6.10 shows the sensitivity of the investment criteria to the assumed adoption rate—senior TAR officials were confident that the present level of technology adoption resulting from the ACIAR projects was 10% and that an annual 3%–5% increase was realistic. The results of this more optimistic

TAR-generated scenario along with a more pessimistic scenario are presented.

Sensitivity testing reveals that even when two important analysis drivers (discount rate and technology adoption rate) are halved, the results of the economic analysis remain positive and continue to indicate a successful investment. If the higher technology adoption rate suggested by senior TAR officials is applied, the total project benefit:cost ratio is 21:1.

Social impact

Social impacts identified during consultation include economic engagement, resilient communities, healthier communities, maintenance of ethnic traditions, social cohesion and gender considerations. Each impact is reviewed separately below.

Table 6.5 Change in producer and consumer surplus—lower and higher altitudes

Metric	Quantum	Source/Comments
Price of milk—P_0	Y9.60/kg	Observed during field investigations There are no government price subsidies on milk or milk products
Quantity of milk—Q_0	643,397,500 kg	Lower altitude milk production is 2,500 kg per farm. According to the Tibet Statistical Yearbook 2013, there are 717 villages in the region. Assuming that each village has 100 smaller farms, each of 14 mu, lower altitude production is 179,250,000 kg Higher altitude milk production is 5,650 kg per farm. According to the Tibet Statistical Yearbook 2013, there are 1,643 villages in the region. Assuming that each village has 50 larger farms, each of 70 mu, higher altitude production is 464,147,500 kg
K-shift	11%	Weighted average of lower and higher altitude estimates shown in Tables 6.3 and 6.4
Elasticity of supply – ε	1.0	See above explanation
Elasticity of demand – η *(absolute value)*	5.0	See above explanation
k	1.07	Weighted average of lower and higher altitude estimates shown in Tables 6.3 and 6.4
Z	0.02	$Z = K\varepsilon/(\varepsilon + \eta)$
ΔPS	Y600,339,109 ($A120,067,822)	$\Delta PS = (K - Z)\, P_0\, Q_0\, (1 + 0.5Z\eta)$
ΔCS	Y120,067,822 ($A24,013,564)	$\Delta CS = P_0\, Q_0\, Z\, (1 + 0.5Z\eta)$

Table 6.6 Additional economic impact data and sources

Metric	Quantum	Source/Comments
Attribution of benefit to IAS projects (%)	65	Total investment (IAS projects plus parallel RD&E investments) shown in Tables 3.1, 3.2 and 3.3 total A$8.746 million, of which IAS projects (ACIAR plus partner investments) total $5.726 million
Counterfactual—delay in IAS project benefits without ACIAR investment (years)	5	Section 6.1 explains how ACIAR investment has 'brought forward' benefits that would have otherwise occurred 5 years later

Table 6.7 Present value of total investment and revenue streams

	Real investment		Adoption rate	Present value (PV) of estimated welfare gains (2014)					
				Producer surplus		Consumer surplus		Total surplus	
	A$m	Ym	%	A$m	Ym	A$m	Ym	A$m	Ym
2005	1.33	6.66	0	0.0	0.0	0.0	0.0	0.0	0.0
2006	1.16	5.79	0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.59	2.95	0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.41	2.04	0	0.0	0.0	0.0	0.0	0.0	0.0
2009	1.00	5.02	0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.89	4.45	0	0.0	0.0	0.0	0.0	0.0	0.0
2011	1.21	6.06	0	0.0	0.0	0.0	0.0	0.0	0.0
2012	1.68	8.42	0	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.00	0.00	0.05	4.10	20.49	0.82	4.10	4.92	24.58
2014	0.00	0.00	0.07	5.46	27.32	1.09	5.46	6.56	32.78
2015	0.00	0.00	0.09	6.69	33.45	1.34	6.69	8.03	40.14
2016	0.00	0.00	0.11	7.79	38.93	1.56	7.79	9.34	46.72
2017	0.00	0.00	0.13	8.76	43.82	1.75	8.76	10.52	52.59
2018	0.00	0.00	0.15	6.42	32.10	1.28	6.42	7.70	38.52
2019	0.00	0.00	0.17	6.11	30.57	1.22	6.11	7.34	36.69
2020	0.00	0.00	0.19	5.82	29.12	1.16	5.82	6.99	34.94
2021	0.00	0.00	0.21	5.55	27.73	1.11	5.55	6.66	33.28
2022	0.00	0.00	0.23	5.28	26.41	1.06	5.28	6.34	31.69
2023	0.00	0.00	0.25	5.03	25.15	1.01	5.03	6.04	30.18
2024	0.00	0.00	0.27	4.79	23.96	0.96	4.79	5.75	28.75
2025	0.00	0.00	0.29	4.56	22.82	0.91	4.56	5.48	27.38
2026	0.00	0.00	0.31	4.35	21.73	0.87	4.35	5.21	26.07
2027	0.00	0.00	0.33	4.14	20.69	0.83	4.14	4.97	24.83
2028	0.00	0.00	0.35	3.94	19.71	0.79	3.94	4.73	23.65
2029	0.00	0.00	0.37	3.75	18.77	0.75	3.75	4.50	22.52
2030	0.00	0.00	0.39	3.58	17.88	0.72	3.58	4.29	21.45
2031	0.00	0.00	0.40	3.06	15.32	0.61	3.06	3.68	18.39
2032	0.00	0.00	0.40	2.27	11.35	0.45	2.27	2.72	13.62
2033	0.00	0.00	0.40	1.54	7.72	0.31	1.54	1.85	9.27
2034	0.00	0.00	0.40	0.88	4.41	0.18	0.88	1.06	5.29
2035	0.00	0.00	0.40	0.28	1.40	0.06	0.28	0.34	1.68
2036	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.00	0.00	0.40	0.0	0.0	0.0	0.0	0.0	0.0
Total (PV)	**8.28**	**41.40**		**104.17**	**520.86**	**20.83**	**104.17**	**125.01**	**625.03**

Economic engagement

ACIAR investment has helped deliver additional income to adopting farm households, reducing the need for them to supplement own-production from local markets and increasing the likelihood of saleable surpluses. Further, specialised enterprises are emerging among farms such as those that just produce fodder.

Resilient communities

Adoption of ACIAR project outputs has increased smallholder engagement in the TAR economy and improved the resilience of village communities. Improved resilience from increased and diversified farm income is associated with a decrease in risk. However, decreased resilience may be associated with the need for specialisation in less-familiar enterprises (e.g. fodder production) and the requirement for exchange to meet basic household needs (e.g. the purchase of grain for household consumption).

Table 6.8 Summary of IAS investment returns

Criterion	Total investment in IAS projects	ACIAR investment in IAS projects
Present value of benefits ($A million)	125.01	65.03
Present value of costs ($A million)	8.28	4.30
Net present value ($A million)	116.73	60.73
Benefit:cost ratio	15.10	15.13

Note: A discount rate of 5% has been used

Table 6.9 Sensitivity to discount rate (total investment, 30 years)

Criterion	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($A million)	151.15	125.01	91.17
Present value of costs ($A million)	7.31	8.28	10.64
Net present value ($A million)	143.84	116.73	80.52
Benefit:cost ratio	20.68	15.10	8.57

Table 6.10 Sensitivity to assumed technology adoption rate by TAR farmers (total investment, 30 years)

Criterion	Present adoption rate and annual increase		
	2.5% present 1% annual increase	5% present 2% annual increase (base)	10% present 4% annual increase
Present value of benefits ($A million)	99.65	125.01	175.71
Present value of costs ($A million)	8.28	8.28	8.28
Net present value ($A million)	91.37	116.73	167.43
Benefit:cost ratio	12.04	15.10	21.22

Healthier communities

The increase in dairy production has resulted in an increase in the availability of butter, cheese and yoghurt for consumption by the farm family, for exchange in the village and for sale in the local or Lhasa market place. Additional nutritious dairy products for own consumption plus any successes associated with bio-fortification of selenium, iodine and other minerals in grains and dairy products will improve the health of TAR rural communities.

Ethnic traditions maintained

The ACIAR projects have enhanced income generation for farmers and improved the nutrition and health of the local community. As cattle raising and butter tea are part of the local Tibetan culture, these projects have also contributed to maintaining Tibetan ethnic traditions (Kaiser et al. 2004).

Social cohesion

Success in communicating project outputs to smallholders may also have improved trust and cooperation between farmers and government officials. Ethnic Tibetans who are benefiting from higher farm incomes, better health, and preservation of a cattle and butter tea culture may feel less alienated by other changes and the rapid economic development in TAR.

Gender considerations

Adoption of ACIAR project outputs has not been without cost to smallholder farm households. Labour is constrained in the farm family, especially during the summer and late autumn harvest months and when the most able males in the farm family seek off-farm employment.

Adoption of relay cropping, fodder cropping and simple dairy nutrition measures falls to already hardworking farm females, who must absorb this additional effort into their work day. Farm profitability analysis (see Section 6.4) shows that an additional 0.2 FTE (at lower altitude) to 0.5 FTE (at higher altitude) of labour is required to implement project outputs. Farm males may have to choose between returns from off-farm income and gains in dairy production.

In the interim, the farm females interviewed are pleased with the additional production and income generated from adopting ACIAR project technologies. Additional farm income has been used for the further education of their children and the purchase of consumer durables such as washing machines. TARI and TLRI staff are confident that the additional returns from milk production are more than able to compete with income earned from off-farm employment.

Environmental impact

The environmental impacts of projects analysed in the IAS were briefly discussed in project-related literature and in more detail during field investigations. Environmental impact was not tracked directly by the projects and, as a consequence, quantitative data are not available.

Potential environmental impacts identified included reduced overgrazing in the rangelands, decreased pressure to expand cropping onto marginal lands, improvement in the utilisation and recycling of nutrients in straw, additional nitrogen fixed in crop soils by vetch and changes in the demand for water. Each impact is reviewed separately below.

Overgrazing in the rangelands

Overgrazing of erosion-prone rangelands adjacent to fertile cropping land is a major environmental challenge for TAR. To this end the government has a policy of halving the number of livestock grazed in the rangelands during the life of its current Five Year Plan by restricting rangeland grazing access and issuing family grazing quotas.

Intensification of cereal production and the freeing up of crop land for fodder production promises to assist with the offsetting of lost rangeland grazing. Working against this improved environmental outcome is the increase in dairy profitability attributable to the ACIAR projects. Over time increased dairy profitability will provide an economic incentive to increase dairy cow numbers and graze them on the rangelands—a common property resource. The final extent of any improvement in the condition of the rangelands will depend on the extent that family grazing quotas are policed. TLRI scientists note that Tibetan livestock officers are somewhat reluctant to police their own people on breaches in grazing quotas.

Expansion of cropping onto marginal lands

Aided by ACIAR project investments, intensification of grain production on fertile cropping land has delivered food security and fodder production, which, in principle, might be expected to at least partially negate any trend toward farmers expanding crop production into more-marginal land. Crop production on marginal land has been shown to result in rapid loss of topsoil due to wind erosion.

This in-principle environmental benefit is somewhat speculative as there is no data from the ACIAR projects or from field investigations in TAR to draw a conclusion on changes in either the rate of expansion of cropping on marginal land or reductions in wind erosion.

Utilisation of nutrients in straw

Using animal manure as both a fuel and a fertiliser for cropping has been traditional practice in the TAR crop–livestock zone for many centuries. A stronger dairy farming sector will produce more manure for fuel as well as fertiliser for crops. Additional manure for fertiliser will improve the utilisation and recycling of nutrients from crop residues and result in a better integrated and more sustainable crop–livestock mixed farming system. In turn this will help to maintain satisfactory crop production levels.

Nitrogen fixing by vetch

Widespread adoption of the legume vetch as a result of ACIAR project investments will benefit soil fertility and structure and capture nutrients remaining after crop production. In 2010 David Coventry (The University of Adelaide, pers. comm., 18 August 2014) was not able to identify any improvement in soil fertility associated with relay cropping of vetch. However, by 2014, TARI scientists reported gains in both fertility and soil structure.

Changes in the demand for water

Adoption of crop intensification recommendations has assisted with the optimisation of cereal growth and the efficient use of water. However, adoption of relay cropping recommendations places greater demands on water resources. It is understood that these two changes to crop production will broadly cancel each other out and there will be no net effect on increasingly scarce TAR water resources.

Australian impacts

Positive impacts were realised for Australia as a result of ACIAR's investment in IAS projects. These included a deeper understanding of the role of straw and stubbles in combination with fodder crops such as vetch and lucerne, and capacity building for Australian scientists and extension professionals. Each impact is reviewed separately below.

Fodder supplementation

The IAS projects have generated useful findings on the amounts of lucerne silage required to augment cereal straw in order to provide cattle with appropriate and cost-effective nutrition. Research findings have the potential to turn surplus cereal stubbles, an agronomic and environmental problem when burned, into a useful feed supplement that will become increasingly valuable during spring droughts when grain is too expensive to feed to livestock (John Wilkins and John Piltz, NSW DPI, pers. comm., 15 August 2014). While benefits initially focused on the cattle industries—beef and dairy—they are also relevant to lamb and other ruminant production.

Professional development

The experience gained by Australian scientists and extension professionals working in a completely different environment with different production systems and through international collaboration has enhanced research capacity in Australia. All Australian researchers consulted as part of this IAS agreed that they had been personally and professionally enriched by the experience of working in TAR.

7 Conclusions

The ACIAR-funded research has provided substantial net benefits for poor rural farmers, particularly those in the crop–livestock zone including the lower altitude prefectures of Shannan and Lhasa and the higher altitudes of the large Xigaze Prefecture. The investment of $A8.28 million (present value terms) by ACIAR and its research partners in four crop- and livestock-related projects has been estimated to produce gross benefits of $A125.01 million (present value terms), providing a net present value of $A116.73 million and a benefit:cost ratio of 15.1:1 (over 30 years using a 5% discount rate). The scale of economic benefits is robust when tested against variations in key adoption and discount rates.

Apart from these estimated economic benefits derived from the projects, there is evidence of social impacts arising from adoption of the project outputs. Increased household incomes are improving the likelihood of greater smallholder engagement in the TAR economy. Success in communicating project outputs to smallholders may also have improved trust and cooperation between farmers and government officials.

However, adoption of the crop–livestock projects' outputs has not been without cost to smallholder farm households. Increased demand for family labour, especially during the summer and late autumn harvest months, coincides with opportunities for able males in the farm family to seek off-farm employment. Consequently, already hardworking farm females in some instances may be absorbing this additional effort into their work day. Nevertheless, the farm females interviewed were pleased with the additional production and income generated from adopting ACIAR project technologies, and cited that additional farm income has been used for the further education of their children and the purchase of consumer durables such as washing machines.

Importantly, a long-lasting impact from the ACIAR projects has been the scientific, project management and institutional design skills that have been developed by participating TAR staff. There is also evidence that these skills are being transferred to others in TAR research and extension institutions, supporting the shift of agricultural research capacity in the region towards best practice.

The impact assessment study findings highlight the importance of understanding impact pathways to ensure engagement and uptake of research outputs by the next users including extension staff. The impact assessment also points to the critical need for strong partnerships between Australian and in-country scientists. While scale-out of the projects' outputs benefited from funding support by PAO, project success was also a function of effective networks and adaptive project management by the research partners. Australian Youth Ambassadors embedded in some projects provided a continual in-country presence and ensured steady progress of project activities. Focusing on the culturally significant dairy industry also contributed to favourable rates of adoption.

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2009. Carol Rose: NSW Grasslands Society meeting, poster.

2009. Carol Rose: Tamworth Research Station, TAR and Australian researchers present.

2010. Carol Rose, NSW DPI Pasture: update.

September 2010. Tim Heath: Masters seminar on potassium nutrition.

March 2011. All project staff: presentations at Adelaide functional linkages meeting.

IMPACT ASSESSMENT SERIES

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 and AS1/1993/222
2	George P.S. 1998.	Increased efficiency of straw utilisation by cattle and buffalo	AS1/1982/003, AS2/1986/001 and 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 and CS2/1989/019
6	Ryan J.G. 1998.	Pigeonpea improvement	CS1/1982/001 and 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 and FST/1988/048
9	ACIL Consulting 1998.	Sulfur test KCL–40 and growth of the Australian canola industry	PN/1983/028 and 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 and 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 and CS1/1988/039
14	McLeod R., Isvilanonda S. and Wattanutchariya S. 1999.	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008 and 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 and 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 Southeast Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004 and AS1/1994/038
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 and AS2/1993/001

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No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and CS1/1988/014
26	Mullen J.D. 2004.	Impact assessment of ACIAR-funded projects on grain-market reform in China	ADP/1997/021 and 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 and 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 and 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 and FIS/1999/076
37	McLeod R. 2005.	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115 and CS2/1996/225
38	ACIAR 2006.	Future directions for ACIAR's animal health research	
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 and 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 and 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 and LWR2/1998/034

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and 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 and 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
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56	Lindner B. and McLeod P. 2008.	A review and impact assessment of ACIAR's fruit-fly 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 and 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 and 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

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
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 and 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 and SMAR/2006/096
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67	Fisher H. 2010.	The biology, socioeconomics and management of the barramundi fishery in Papua New Guinea's Western Province	FIS/1998/024
68	McClintock A. and Griffith G. 2010.	Benefit–cost meta-analysis of investment in the International Agricultural Research Centres	
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