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Australian Centre for International Agricultural Research

Adoption of ACIAR project outputs

2017

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Editors

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Research that works for
developing countries and Australia

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. ACIAR operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. It commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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ACIAR Adoption Studies

ACIAR seeks to ensure that the outputs of the research it funds are adopted by farmers, policymakers, quarantine officers and other beneficiaries. As part of its efforts to monitor the outputs and outcomes of its projects, ACIAR commissions project leaders and participants to revisit projects 3–4 years after completion, and report back to ACIAR on the medium-term outcomes of the work. The Adoption Studies series of publications reports the results of these studies. The series is distributed internationally to selected individuals and scientific institutions, and is also available from the ACIAR website at <aciar.gov.au>.

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Research collaborator Nurislam and his daughter by N. Dalgliesh

Supriani feeds fodder to her cattle inside the communal cattle shed in Karang Kendal hamlet by Conor Ashleigh

James Maora, Matthew Poienou and Simon Minnah by ACIAR

Foreword

As part of its ongoing evaluation process, the Australian Centre for International Agricultural Research (ACIAR) periodically revisits a sample of past projects some time after their completion—typically three or four years for large projects—and critically appraises their outcomes. ACIAR commissions these appraisals to determine the level of uptake of the project outputs and gauge the extent of the projects' legacies. The appraisers study the outputs under three broad categories: the emergence of new technologies or practical approaches to tackling problems; the gaining of new knowledge that would lead to better understanding of scientific and socioeconomic aspects of agriculture; and the introduction of new models and frameworks to assist policymakers in reaching decisions that influence the environment of farmers and others along the market chain.

This report, the 14th in our series of adoption studies, documents the adoption results for four ACIAR projects completed in 2012–13. They involved three partner countries— Bangladesh, Papua New Guinea (PNG) and Indonesia. One project was crop related, involving wheat in Bangladesh; two were related to livestock—broiler chickens in PNG and cattle in Lombok Indonesia; the fourth concerned forestry in PNG.

Bangladesh has serious concerns about its food security and needs to produce more. While its land is extensively farmed, an estimated 850,000 ha of southern land lies fallow each rabi season (the drier months November to late March). A project to investigate the potential for increasing wheat and mung bean production on this land led to a seed multiplication trial program to extend knowledge of modern varieties and good agronomic practice both to the farming community and within the government and non-government research and extension communities. The impact of this trial program already can be seen in the increased farmer numbers and higher crop production that have occurred over the past six years. As well, Bangladesh policy makers encouraged by these results now give their support to continuing departmental initiatives for the region.

In PNG the cost of feeds derived from imported ingredients constrains the production of broiler chickens. Researchers have developed a suitable diet based on a locally-produced nutritional concentrate mixed with either sweetpotato or cassava (according to local availability). This successful outcome promises to have wide potential for both broiler and layer hens in PNG but the major obstacle to adoption is presently the shortfall of locally produced nutritional concentrate.

ACIAR has sponsored a suite of projects over many years to improve beef production and markets in eastern Indonesia; the project team conducting a study on Lombok Island sought to scale-up herd management strategies for smallholder producers. Based on many years of experience the team has developed a realistic technology package to maximise reproductive potential and convert this into greater turn-off of marketable animals, without overt strain on limited resources such as land to grow forage and space to house additional animals. The team has equipped an On Ground Team (a group of graduates with responsibility for technical advice and engagement with farmers) and this is turning into a key operative for introducing and maintaining improved practices. The project has had significant influence on key policies and programs at provincial and district levels.

The forestry project in PNG has developed opportunities for landowners in the study regions to expand their tree-growing activities. So far adoption of project outcomes has been largely limited to the landowners directly involved in the research trials. But the capacity built in partner institutions, knowledge of suitable species, greater understanding of landowners' attitudes to and motivations for commercial tree growing are contributing to PNG's future forestry directions and fit with national plans to produce biofuels for sustainable power generation. The PNG Tree Growers Tool Kit proved particularly valuable. Other significant outputs included the planting of a demonstration plantation of teak and the establishment of plots of *Eucalyptus pellita* in the Upper Markham and Ramu valleys. There is now a community nursery in the Upper Markham, and 100,000 eaglewood (*Gyrinops ledermannii*) trees established in the Western Province.

The authors found that there are medium levels of adoption in all four projects in the study, and they have drawn upon their findings to provide some useful lessons and observations.

Andrew Campbell
Chief Executive Officer, ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
APSIM	Agricultural Production Systems sIMulator
BARI	Bangladesh Agricultural Research Institute
BPTP	Balai Pengkajian Teknologi Pertanian (Indonesia)
BSS	Bumi Sejuta Sapi (Indonesia)
CLTC	Christian Leaders Training College (Papua New Guinea)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTA	Technical Centre for Agricultural and Rural Co-operation
DAE	Department of Agricultural Extension (Bangladesh)
DFAT	Department of Foreign Affairs and Trade
FAO	Food and Agriculture Organisation
GM	gross margin
IRRI	International Rice Research Institute
Lao PDR	Laos People's Democratic Republic
LDS	Lutheran Development Service
NARI	National Agricultural Research Institute (Papua New Guinea)
NGO	non-government organisation
NTB	Nusa Tenggara Province (Indonesia)
OGT	On Ground Team
OTDF	Ok Tedi Development Foundation
PAC	Program Advisory Committee
PGPD	Painim Graun na Planim Diwai (Papua New Guinea)
PNG	Papua New Guinea
PST	Project Specialist Team
SARDI	South Australian Research & Development Institute
SMT	Seed Multiplication Trial (Bangladesh)
SWIM	Soil Water Infiltration and Movement
UNRAM	University of Mataram (Indonesia)
WRC	Wheat Research Centre (Bangladesh)

Overview

David Pearce and Andrew Alford

Introduction

This report summarises the adoption results for four Australian Centre for International Agricultural Research (ACIAR) projects completed in 2012–13. The projects involved:

- three partner countries—Indonesia, Bangladesh and Papua New Guinea (PNG)
- one forestry-related project in PNG
- one crop-related project—wheat in Bangladesh
- two livestock-related projects—chickens in PNG and cattle in Indonesia.

The outputs from the projects were diverse, ranging from the establishment of forestry genetic resources (in PNG) to technology packages for cattle (in Indonesia). The projects reported in this publication reflect a broad balance of technology, policy and knowledge outputs.

Most of the projects also involved capacity building in partner countries and institutions, ranging from formal university-based training to a variety of on-the-job training activities for technical staff, research scientists, non-government organisations (NGO) and farmers.

The four adoption studies generally indicated medium levels of adoption of the project outputs. For each project, the adoption results provided some useful lessons and observations.

Project outputs—what was discovered

ACIAR's adoption studies classify outputs into three broad categories:

- **new technologies or practical approaches** for dealing with particular problems or issues, which are designed to be applied ultimately at the farm, processing or marketing level, or in some cases at the breeder level
- **new scientific knowledge or basic understanding** (pure or basic science) of the phenomena or social institutions that affect agriculture, which are designed as inputs into further research processes, ultimately to help in the future development of practical approaches for smallholders, processors, wholesalers and retailers
- **knowledge, models and frameworks for policymakers** or broad-level decision-makers, which are not necessarily for use at the farm level but will influence the contextual environment in which farmers, processors, wholesalers and retailers must operate.

Given the diversity of ACIAR-funded research, there is considerable overlap between these categories, and many projects contribute to more than one category. Table 1 summarises the outputs for the four projects covered in this report.

New technologies or practical approaches were the major outputs for the four projects. These were targeted at the farm level. New technologies and approaches at the farm level included:

- provision of genetic resources
- identification of rabi-season wheat varieties for southern Bangladesh
- formulation and demonstration of low cost diets for broilers.

New scientific knowledge—in particular, social science and economic knowledge—was an important output from three of the projects. New knowledge included economic models of feed systems, economic analysis of rabi-season cropping and enhanced understanding of adoption processes.

Knowledge or models relevant to policymakers were also developed by the projects. These included improved understanding of landholder attitudes in PNG, demonstration of rabi-season viability in Bangladesh and development of stakeholder engagement mechanisms in Indonesia.

Table 1: Summary of project outputs

Project	New technologies or practical approaches	New scientific knowledge	Knowledge or models for policy and policymakers
Value adding to PNG agroforestry systems	Establishment of genetic resources and demonstration plantations Establishment of community nursery plantation Publication of *PNG Growers Took Kit*	New information on landowner adoption decision processes	Improved understanding of landowner attitudes to, and motivations for, tree growing
Expanding the area for rabi-season cropping in southern Bangladesh	Identification and testing of modern wheat and mungbean varieties Demonstration of the diversity and flexibility of these crops in southern Bangla cropping systems	Economic analysis demonstrated viability of rabi-season cropping Soil water management learnings that enable the crops to be grown in the rabi-season	Demonstration of viability of rabi-season cropping to policy makers
Improving the profitability of village broiler production in PNG	Formulation of low cost diets for broiler production suitable to local conditions Development of extension material	Economic models of feed costs New information on effectiveness of diets drawing on locally available feed resources	—
Scaling up herd management strategies in crop-livestock systems in Lombok	'Technology package' set of practices in communal facilities (kandangs)	Enhanced understanding of adoption processes	Development of stakeholder engagement mechanisms

Capacity development

Most projects studied in this report had explicit or secondary objectives to improve the capacity for research and development in partner countries. Table 2 summarises the capacity built and used in the projects.

Capacity development included both formal training (university-level degrees) and on-the-job and informal training. Training ranged from advanced topics, such as system simulation modelling, to improvements in extension skills.

In most cases, the research capacity and research infrastructure continue to be used after the project is complete. The collaboration developed between organisations often remains in place, and staff skills and expertise developed through training continue to be used.

Table 2: Research capacity built by the projects and its continued use

Project	Research capacity built in partner country(ies)	Research infrastructure	Capacity used
Value adding to PNG agroforestry systems	Completion of 3 graduate degrees Skills development of project researchers	—	Graduates and other researchers continue to play a key role in forestry activities in PNG
Expanding the area for rabi-season cropping in southern Bangladesh	Development of simulation modelling capacity	Database of soils and climate	Capacity used for ongoing analysis of soil and cropping systems
Improving the profitability of village broiler production in PNG	Increased capacity of NARI and Unitech researchers and NGO staff to understand feed formulation, and motivation of farmers	Infrastructure to conduct on-station grow-out trials was developed at three NGO sites	Capacity developed continues to be used in NARI interactions with farmers
Scaling up herd management strategies in crop-livestock systems in Lombok.	Improved capacity to support uptake of practices through: On Ground Team (OGT); and Project Specialist Team (PST)	—	Members of OGT continue to be employed by the government, some in livestock roles and other elsewhere

Uptake of outputs—progress along adoption pathways

Most of the projects had a number of different objectives and outputs. Summarising the often complex adoption outcomes for a range of projects is difficult and involves an element of judgement. For the summary in Table 3, a four-level classification scheme has been used (as in previous adoption reports) to indicated no, low, medium or high uptake.

1. The lowest level of adoption is ***O* or no uptake** of the results by either initial or final users of the outputs of the project. Three projects had no adoption of some project outputs, although there was low to medium adoption of other outputs.
2. The next level of adoption is ***N* or low uptake**, in which there was some uptake by initial users but not by final or ultimate users of the research. All projects had some outputs in this category, although other components had higher levels of adoption.
3. The next level of adoption is ***Nf* or medium uptake**, in which there has been uptake by initial users and some uptake by ultimate users. There was one project with an output in this category.
4. The highest level of adoption, ***NF* or high uptake**, by initial and final users, was achieved in some components in three projects.

Table 3: Current levels of adoption of key project outputs

Project	New technologies or practical approaches	New scientific knowledge	Knowledge or models for policy and policymakers
Value adding to PNG agroforestry systems.	***O***—teak germplasm ***NF***—eucalypt plantation ***N***—community nursery ***O***—eaglewood trees ***NF***—*Tree Growers Tool Kit*	***N***	***N***
Expanding the area for rabi-season cropping in southern Bangladesh.	**NF**	**N**	**Nf**
Improving the profitability of village broiler production in PNG.	**O**—low cost diets	**N**—models of feed costs and knowledge of effectiveness of local diets	—
Scaling up herd management strategies in crop–livestock systems in Lombok.	**N**	**O**	**NF**

O No uptake by either initial or final users.
N Some use of results by the initial users but no uptake by the final users
Nf Demonstrated and considerable use of results by the initial users but only minimal uptake by the final users
NF Demonstrated and considerable use of results by the initial and final users

Factors influencing adoption and impact

Many factors underlie particular adoption outcomes, and they can be summarised as follows.

- **Knowledge**
  - Do the final or ultimate users *know* about the project outputs?
  - Is there *continuity* of staff in organisations associated with adoption, leading to the ongoing transfer of knowledge?
  - Are the outputs *complex* compared with the capacity of users to absorb them? (Do users have a sufficient knowledge base to support adoption?)
- **Incentives**
  - Do users have sufficient *incentives* to adopt the outputs?
  - Does adoption of the outputs increase *risk or uncertainty* for the users, thus reducing incentives to adopt?
  - Is adoption either *compulsory* or indirectly *prohibited*? (Are there extreme forms of incentives or barriers?)
- **Barriers**
  - Do potential users face *capital or infrastructure constraints*, limiting their ability to fund the adoption of the outputs?
  - Do potential users face *cultural or social barriers* to adoption?

Table 4 summarises the key findings about factors affecting adoption for the projects studies in this report.

Table 4: Factors influencing adoption and impact—summary of key findings

Factor		Key findings
Knowledge	Do potential users know about the outputs?	Not identified as a constraint for these projects
	Is there continuity of staff in organisations associated with adoption?	Not identified as a constraint for these projects
	Are outputs complex in comparison with the capability of users?	Lack of potential user capacity identified as an issue in the PNG forestry project
Incentives	Are there sufficient incentives to adopt the outputs?	Lack of market demand identified as an issue in the PNG forestry project The technology package for livestock on Lombok was structured so as to be matched to incentives
	Does adoption increase risk or uncertainty?	Not identified as a constraint for these projects
	Is adoption compulsory or effectively prohibited?	Not identified as a constraint for these projects
Barriers	Do potential users face capital or infrastructure constraints?	Policy constraints at the national level are an issue for the PNG forestry project There is some evidence that broiler farmers and feed mixers in PNG face capital constraints
	Are there cultural or social barriers to adoption?	There is mixed evidence on the importance of cultural constraints for the broiler project in PNG

Lessons

The results from the adoption studies reported here provide a number of lessons for ACIAR-funded projects.

Markets and private sector interaction are crucial

The PNG forestry project illustrated the importance of markets for products as well as commercial involvement. While some landowners are early adopters of new approaches, wider adoption requires a clear financial benefit which will only be achieved through the establishment of markets for the product along with commercial intermediaries to provide market signals to landowners.

Care needed in choosing research participants

The broiler feed project in PNG illustrated the importance of the choice of research participants. This project emphasised the importance of choosing farmer participants that were able to take action, were accessible and reliable, and had sufficient motivation to participate.

The importance of broad engagement

Researchers in the rabi-season cropping project in Bangladesh noted that were they to do the project again they would undertake considerably broader engagement with the farming community to increase the diversity (particularly gender diversity) of the participants

The engagement in PNG with Ok Tedi Development Foundation (OTDF) demonstrated the risks, frequently experienced in developing country settings, with limited technical capacity where two unfortunate personnel disruptions greatly limited scaling out beyond the immediate trial landowners.

Resources for extension

The herd management project in Lombok, Indonesia, noted that limited resourcing to public extension agencies and lack of incentives and training for extension officers limits their capacity to engage research activities. This means that within projects, alternative or additional mechanisms for dissemination of beneficial research outcomes need to be considered. These may include partnering with the private sector or existing civil society organisations or explicit funding of farmer champions for dissemination. The Lombok project also noted that the 'on ground team' (OGT) model of employing, training and mentoring a project team proved to be successful.

Expectations for policy influence

Expectations for significant policy influence from a three-year research project should be moderate. The Lombok project noted that policy influence at the provincial level was the result of the strong networks built by the Lombok team, and continued activity and engagement with the farming community over 15 years.

National policy influence, however, would require extensive institutional engagement. There is an important role for ACIAR to engage with the central government regarding national and provincial priorities and investments for cattle production, with the aim of creating a more supportive policy environment for the ACIAR suite of livestock research activities in Indonesia.

Research into institutional settings

An area of research that may have widespread utility is to document the different institutional settings associated with cattle production in Indonesia and the mechanisms available to influence policy, the aim of which would be to analyse and compare the scope, advantages and disadvantages of engagement with different mechanisms. This understanding would support more targeted and informed policy engagement and may help close a gap between research outcomes and policy direction, improve the effectiveness of Australian-funded research in livestock production and provide a more efficient policy pathway to improved livelihoods for smallholders, politics of policy making notwithstanding.

Value-adding to PNG agroforestry systems

Professor Peter Kanowski, Fenner School of Environment and Society, The Australian National University

Dr Kulala Mulung, Deputy Managing Director, PNG Science and Technology Council Secretariat

Project number	FST/2004/050
Project title	Value-adding to PNG agroforestry systems
Collaborating institutions	The Australian National University, Ok Tedi Development Foundation, Pacific Islands Projects, the PNG Forest Authority, the PNG University of Technology, Ramu Agri Industries, Village Development Trust
Project leaders	Peter Kanowski, The Australian National University Francis Vilamur, PNG Forest Authority Kulala Mulung, Eko Maigo , PNG University of Technology
Project duration	April 2007 to March 2012
Funding	A$1,405,053 total (ACIAR contribution A$912,087)
Countries involved	Australia, Papua New Guinea
Commodities involved	Wood
Related projects	FST/2009/016 Improving the Papua New Guinea balsa value chain to enhance smallholder livelihoods FST/2011/057 Enhancing the implementation of community forestry approaches in Papua New Guinea FST/2014/069 Improvement and management of teak and sandalwood in Papua New Guinea and Australia

1. Motivation—what the project aimed to achieve

The research was motivated by the recognition, in ACIAR's then PNG Forestry Strategy and related consultations and reviews, of a number of paradoxes in relation to landowner (*syn.* "smallholder") tree growing and wood availability in PNG. The first of these was evident capacity of PNG landowners to integrate tree growing in their farming systems, apparent in a diversity of forms across the PNG mainland and islands; but the very limited adoption of commercial tree growing in these systems. The second was the projected shortage of wood in a forest-rich country, resulting from decades of unsustainable harvesting and in some places, maintenance of low-productivity anthropogenic grasslands. The third was the continuing dependency of some 85% of the PNG population on livelihoods derived primarily, and often exclusively, from their customary land, but their lack of capacity to capitalise on that land to improve their livelihoods. The project was situated at the intersection of these issues.

Project objectives defined in this context were to:

1. define commercial tree production systems for priority species in a number of pilot regions
2. assess landowner decision-making in the context of candidate tree species and production systems
3. develop business models and strategies to facilitate adoption, in conjunction with investment and implementation partners
4. implement strategies in the pilot regions in conjunction with landowners and investment and implementation partners
5. communicate project knowledge and learning to interested parties outside pilot regions.

The project was designed to capitalise on and develop partnerships with key non-government actors with established tree-growing activities in particular target regions of PNG. These were the Ok Tedi Development Foundation (Western Province) (OTDF), Ramu Agri-Industries (Ramu/Markham) and the Village Development Trust (Lae and Madang). The lead PNG partner was the Department of Forestry of the University of Technology (UniTech). Each of these partners had been engaged in prior discussion with the ACIAR Forestry Program Manager, and Ramu Agri-Industries was already a partner in other ACIAR projects.

2. Outputs—what the project produced

The principal project outputs related to:

- germplasm, nurseries and plants for landowner establishment
- knowledge about PNG landowners' attitudes to and motivations for commercial tree growing, and knowledge about specific tree growing activities
- capacity development at a number of levels.

Germplasm, nurseries and plants

- Establishment of circa 50 ha of teak (*Tectona grandis*) sourced from Lao PDR, Thailand and Solomon Islands, in a series of single-origin stands in the Upper Markham and Ramu valleys. These stands represent significant genetic resources for future planting and breeding of teak in PNG.
- Establishment by landowners and communities in the Upper Markham and Ramu valleys of circa 25 ha of pellita (*Eucalyptus pellita*), sourced from various PNG stands, that serve as livelihood assets, genetic resources and demonstration plantings.
- Establishment of a community nursery near Marawasa village in the Upper Markham, led by UniTech with assistance and ongoing support from Ramu Agri-Industries.
- Planting of circa 100,000 eaglewood (*Gyrinops ledermannii*) trees by landowners in Samagos (North Fly), Aiambak (Middle Fly) and Nakaku (South Fly) areas of Western Province.

Knowledge

- An understanding of landowner attitudes to and motivations for tree growing, and of the implications for actors promoting commercial tree growing. These outputs were reported in Kulala Mulung's PhD thesis, *Papua New Guinea landowners' decision processes relevant to commercial tree growing*, and conference papers associated with it.
- A series of knowledge products directed at landowners and those working with them, about each stage and specific element of growing commercial trees. These were made available in printed copy and online, and compiled as the *PNG Tree Growers Tool Kit*.

Capacity

- Completion of graduate degrees by three John Allwright Fellows, and the completion of a John Dillon Fellowship.
- Knowledge and skill development of other PNG project researchers in the private and university sectors.
- Strengthening the capacity of the UniTech Department of Forestry to engage in partnership research projects.

- Further development of linkages between other PNG project partners—Pacific Islands Projects, OTDF and Ramu Agri-Industries—and Australian researchers.
- Expanding the base of Australian researchers working on PNG forestry issues, and fostering their partnership with PNG colleagues;
- Development of landowner awareness of and skills relevant to tree growing, including seedling and clonal production, in some Upper Markham communities—principally Marawasa, Ragigumpuah and Wangkung. Some 200 landowners planted trees; adoption has continued in these and some other Upper Markham communities.

3. Adoption—how the project outputs are being used

Capacity

Capacity built by the project can be categorised as that at individual researcher, institutional and landowner levels. The first of these categories has led to major adoption, and some adoption has been generated directly in the other two categories.

Individually, each of the three John Allwright Fellows associated with the project has had, or is having, major impacts on adoption. Dr Kulala Mulung was instrumental in helping shape the early stages of the PNG Biomass Project, both in its approach and use of project genetic resources. Ms Gorethy Dipsen now plays a leading role in facilitating the PNG Biomass Project's plantation expansion in the Upper Markham, and is an active member of PNG Women in Agriculture. Dr Francis Essacu is teaching courses related to project outputs at the PNG University of Technology. Most other project researchers have continued to work on related topics in PNG.

At the institutional level, the project strengthened the capacity of the UniTech Department of Forestry to offer a postgraduate program and to engage in partnership research projects, including with ACIAR.

At the landowner level, capacity development has been limited primarily to those landowners who participated in project activities and training. These landowners are primarily those in the Upper Markham communities of Marawasa, Ragigumpuan and Wangkung.

Technical outputs

Ramu Agri-Industries, which was a key partner in establishing technical outputs, has shifted its focus away from direct or partnership commercial tree growing to planting for Roundtable on Sustainable Palm Oil certification requirements. However, it remains an important custodian of genetic resources. The teak germplasm established by the project is not yet being adopted more widely; however, these resources will provide an important genetic base when teak planting expands in PNG. Adoption of *Eucalyptus pellita* planting by landowners in some Upper Markham communities is continuing, but not on a large scale independent of external actors. The *E pellita* stands established by the project in conjunction with landowners have provided a significant component of the genetic resources for the initial phases of the PNG Biomass Project, which has established c 900 ha to date of a total planned extent of 15,000ha. The PNG Biomass Project represents the major adoption pathway for project outputs in the Markham Valley. It has also emulated the project's community nursery model, establishing the first of its community nurseries at Ganef in the Lower Markham Valley, and expanding the Marawasa community nursery established by the project.

In Western Province, adoption of tree growing has not expanded beyond landowners who received plants from OTDF. Adoption has been constrained by a loss of forestry capacity in OTDF due to the death of one project team member and the resignation of another.

Knowledge outputs

The PNG Tree Growers Tool Kit expanded with addition of resources from other ACIAR projects, and the kit is now the principal such resource in PNG. It provides the technical resources for the ambitious national Operation Painim Graun na Planim Diwai (PGPD), under the *PNG Vision 2050*.

Both Operation PGPD and the ITTO Gomore Project (ITTO PD 552/09; Central Province) draw on knowledge generated by the project about strategies for working with landowners and communities.

4. Impact—the difference the project will or may make

While the direct impacts of project FST/2004/050 have been limited, primarily to improvements in the livelihoods of small numbers of landowners and communities in the Upper Markham Valley, the indirect impacts in the valley are substantial, and potentially transformative in various respects.

A major new tree-growing actor in the Markham Valley, PNG Biomass[1], has emerged since project completion. PNG Biomass has been in development since 2012, and plans to establish 15,000 ha of tree plantations in the Markham Valley to supply a biomass power plant that will operate from 2019 at a site in the mid-Markham. This project has strong political support; it is part of the new national government's 'first 100 days' program, and is currently in the final stages of investment commitment by its parent company, Oilsearch. The PNG Biomass project relies in large part on partnerships with landowners; it has been substantially enabled by knowledge, capacity and genetic resources developed by the project, and in some cases the enabling local environment fostered by the project.

Thus, the impacts of project FST/2004/050 are principally:

- material improvements in the livelihoods of small numbers of landowners and communities in the Upper Markham Valley
- catalysing the planting of trees in both the Upper Markham and Upper Ramu valleys and in the mine-impact area of Western Province, which will contribute to future livelihood benefits, and in the case of teak in the Upper Markham and Upper Ramu valleys, a major genetic resource for PNG
- a successful development phase of the PNG Biomass project—it is not likely that this project could have reached its current status without the platform developed by FST/2004/050 in respect of knowledge, capacity and genetic resources. The project represents a scaling-up of tree growing in the Markham Valley which is potentially transformative for landowner attitudes to and benefits from tree growing in the region, to the related issue of the use of fire in land management, and to the realisation of the aspirations of Operation PGPD nationally
- the knowledge about landowner decision-making that has informed policy frameworks and mechanisms for the national Operation PGPD, and related projects
- professional capacity development in research, facilitation of landowner engagement, and tree growing; and landowner capacity development for a small number of landowners and communities in the Upper Markham Valley
- knowledge resources that inform tree growing nationally, and underpin the aspirations of Operation PGPD
- strengthening the capacity of the UniTech Department of Forestry staff to engage in partnership research projects, and enhancing the relevant course content.

In relation to realised and prospective impacts, it is evident that:

- as noted in the final report of FST/2011/057, the direct impacts of FST/2004/050 are largely limited to a relatively small number of landowners and communities in the Upper Markham Valley, and in Western Province
- the major impacts of FST/2004/050 are being realised more through the development and communication of knowledge about and capacity for how external actors might best work with landowners, the provision of foundational genetic resources, and demonstration of the benefits of adoption in some communities; and the scaling-up of planting based on that knowledge, attitudes and genetic resources

1 see http://pngbiomass.com

- while the direct impacts of FST/2004/050 on participating communities are limited, to date; the indirect and longer-term benefits to those and other Markham Valley communities are potentially very significant. The demonstration value of PNG Biomass project success to large-scale tree growing ambitions in PNG is also very significant
- results demonstrate the importance of a commercial actor to the scaling-up of landowner tree growing. As the FST/2004/050 Scoping Study and Proposal noted, PNG landowners are adept at innovation where they have the motivation and means to do so. Some landowners and communities demonstrated such motivation in partnership with FST/2004/050, and have sustained it since the completion of FST/2004/050. They have seen cultural and livelihood benefits from tree growing. However, more widespread adoption beyond these early adopters depends on a much wider group of landowners being informed and convinced of the benefits of tree growing; this, in turn, depends on the development of a market for trees and of a facilitating entity operating on a larger scale.

Expanding the area for rabi-season cropping in southern Bangladesh

Mr. Neal Dalgliesh, formerly CSIRO Australia
Dr. Md. Saifuzzaman, formerly Bangladesh Wheat Research Centre
Dr. Md. Jahangir Kabir, Bangladesh Rice Research Institute
Dr Sk. Md. Abdus Sattar, formerly Bangladesh Rice Research Institute

Project number	LWR/2005/146
Project title	Expanding the area for rabi-season cropping in southern Bangladesh
Collaborating institutions	CSIRO, Australia; Bangladesh Agricultural Research Institute (BARI) through the Wheat Research Centre (WRC) and On-Farm Research Divisions (OFRD); Bangladesh Department of Agricultural Extension (DAE); PROSHIKA Bangladesh Forum for Regenerative Agricultural Movement (FoRAM); Socio-Economic Research and Development Initiative (SERDI); International Maize and Wheat Improvement Center
Project leaders	Dr Peter Carberry, CSIRO Mr Neal Dalgliesh, CSIRO
Project duration	January 2006 to February 2011
Funding	A$1,913,419 (ACIAR contribution A$1,082,094)
Countries involved	Australia and Bangladesh
Commodities involved	Wheat and pulses (particularly mungbean)
Related projects	LWR2/1994/032 Nutrient and irrigation management for sustainable rice–wheat cropping systems in Bangladesh and Australia LWR/2005/001 Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh

1. Motivation—what the project aimed to achieve

In 2006, Bangladesh wheat consumption was approximately four million tonnes per annum and increasing at an annual rate of 3%, whereas production was less than two million tonnes and decreasing. The situation created serious concerns for food security and for diminishing foreign currency reserves. Bangladesh is a relatively small country with a large population and while agricultural land is at a premium and extensively farmed there was an estimated 850,000 ha of southern land laying fallow during the *rabi* season. This area was considered by some to have potential for the production of wheat and pulses, however this view was against the majority which argued that Bangladesh wheat production had a northern focus for very good reason—the environment and the soils were better suited, there was good irrigation infrastructure, wheat varieties were well adapted and farmers were experienced. In comparison, it was argued that the south was limited by soil salinity, a shorter growing season and high seasonal temperatures, a lack of groundwater for irrigation and inexperienced farmers.

However, Food and Agriculture Organisation (FAO) research undertaken between 2003 and 2005, suggested that a reappraisal of southern wheat growing potential was warranted. The research indicated that the yields of newly-introduced wheat varieties could yield on average 2.5 t/ha, and up to 4.0 t/ha through earlier than recommended planting, made possible by mechanisation and by utilising surface-stored water for limited irrigation. These findings were supported in a 2006 ACIAR scoping study which demonstrated that yields of 2.5 t/ha were possible in some locations, even under rainfed conditions. Empirical results were supported by cropping systems simulation, based on long-term weather records for southern Bangladesh, which indicated that wheat, mungbean and maize could all be grown with low-risk and long-term economic feasibility, particularly if surface water, stored over the monsoon season could be used to irrigate the crop once soon after establishment. This analysis showed that wheat, double cropped with mungbean was likely, in most years, to be twice as economically rewarding as maize.

Assuming that 50% of the 850,000 ha of available fallow land was used to grow rabi-season crops, the analysis suggested there was potential for the south to contribute an additional one million tonnes of wheat to food security (assuming an average yield of 2.5 t/ha). It was also considered that increasing southern productivity would flow through to increased regional business activity and wealth including improvement to the livelihoods of the farming families.

As a result of these findings, the ACIAR project, *Expanding the area for rabi-season cropping in southern Bangladesh*, commenced in 2006 with the remit to investigate the potential for southern Bangladesh rabi-season wheat and mungbean production utilising fallow lands and associated water resources. Given its organisational experience, expertise and past collaboration, the Bangladesh Agricultural Research Institute (BARI) was the logical choice for collaboration, in particular the Wheat Research Centre (WRC) and the On-Farm Research Division. The Bangladesh Department of Agricultural Extension (DAE) and PROSHIKA, an NGO active in the south, were identified as key project partners to facilitate the extension of results.

The confirmation of land availability and its suitability for crop production was an early priority. Once confirmed, progression to the development of appropriate agronomic practice was required to ensure that the advantages of modern varieties, appropriate nutrition, timely crop establishment and efficient use of available ground and surface water were available to optimise production and economic gain. In a linear research and extension model, it might be expected that the latter-part of the program would focus on the scaling-out of promising research interventions, however, in effect, the use of an on-farm research approach allowed researchers and collaborating farmers to continually investigate potential interventions and to modify local practice as dictated by the research findings. This led to rapid and continuing farmer uptake.

2. Outputs—what the project produced

Technical

Systems issues, varietal selection and on-farm research (intended)

Rabi season environmental screening of modern wheat varieties (Shatabdi, Prodip, Sourav, Bijoy) and promising pre-release lines (BARI GOM 25, 26) undertaken over three years, at six geographically diverse southern sites showed that yields greater than 3.0 t/ha were achievable where soil salinity was low, WRC-recommended rates of fertiliser were used and one application of 100 mm of irrigation was applied. This was despite seasonal temperatures being higher and the growing season shorter than in the northern wheat growing regions. Importantly, wheat was also able to be planted from the middle of November through until the middle of December without significant yield reduction. Also, the modern varieties matured five days earlier from a November sowing (100 days to maturity) and 15 days earlier from a late December plant (90 days to maturity) compared to the north. While yields were lower and more variable in the more saline environments, average irrigated yields still exceeded 2.0 t/ha with individual crops yielding as high as 3.45 t/ha. Dryland crops generally yielded between 500 and 1000 kg/ha lower than their irrigated counterparts.

The mungbean variety, BARI Mung 6 yielded 5–12 t/ha when grown under good seasonal conditions. However, over three seasons of research and on-farm demonstration, growing mungbean as a double crop following wheat resulted in significant yields being achieved in only 29% of cases due to poor agronomy and seasonal variability.

The Seed Multiplication Trial (SMT) program provided the venue to both demonstrate the potential for the modern wheat and mungbean varieties and to produce seed, which growers were then free to sell to their peers. Over four seasons, 285 farmers in seven districts (in Barisal and Chittagong divisions) participated in the SMT program which provided a low cost, low risk opportunity to grow the crops while receiving financial gain through crop production and seed sales. This research showed that mean irrigated wheat yields of 3.0 t/ha were achievable in low salinity environments across the south, while moderate salinity levels reduced average yield to 2.1 t/ha. Importantly, these yields could be achieved with one strategically timed irrigation application at 20 days after sowing, which was contrary to expectations and observations from northern Bangladesh where multiple irrigations are required to optimise production. Understanding the differences in the regional systems resulted from detailed ground water research, backed up by simulation modelling which showed that ground water, through capillary rise supplied between 60 and 105 mm of available water to a rabi-season wheat crop, translating into yield increases of 0–1.5 t/ha.

The SMT program in conjunction with systems modelling also showed that mungbean could be grown in sequence with rice and wheat if a strategic approach was taken to mitigate risk. Mungbean needed to be seen as an 'opportunity' crop to be planted before the end of March but only in the presence of sufficient soil moisture to ensure germination. Analysis showed that the crop should not be planted after the end of March due to the risk of catastrophic weather events. If an 'opportunity' did not arise, it was suggested that an alternative crop such as T. Aus (Kharif 1) rice be considered or mungbean planted as a sole rabi-season crop in January/February.

Social and economic evaluation (intended)

Understanding the drivers of technology adoption by farmers was critical to improving their livelihoods, in this case through the modification of the farming system. Research indicated that there was an overarching social dimension to technology adoption, which may determine overall success or failure. While farmers saw new cropping options as financially profitable and a preferred farmer livelihood option, they indicated that adoption was unlikely to occur unless knowledge and experience were developed through the provision of extension strategies that catered for the social and gender diversity found in villages. This included enhancing the adaptive capacity of farmers through external assistance and multi-faceted cross-sectoral partnerships of government, NGO and community, and the availability of resources including labour, quality seed, equipment and financial services.

An economic analysis undertaken in villages in Bhola and Noakhali districts confirmed the viability of rabi cropping in southern Bangladesh. While current rabi-season crops were profitable under most seasonal conditions, it was confirmed that wheat added a profitable and low financial risk option to the system. This survey also indicated that rice production was paramount in terms of food security, with the monsoon crops being most important and a lack of reliable irrigation hampering rabi-season Boro rice production. As a consequence, rabi-season cropping emphasis was on the production of rainfed crops, particularly pulses and chillies, although potatoes, wheat, cowpea and grass pea were also cultivated. At this time wheat was not a significant crop in Noakhali district although farmers in parts of Barisal division had some past experience. Gross margin analysis of individual rabi-season crops grown in Bhola indicated that in a normal rabi season, the highest gross margin) was from wheat, followed by grass pea, Boro rice, mungbean and cowpea. High production costs and poor market price impacted on Boro rice gross margin.

Policy (intended)

A major constraint to acceptance of research outcomes was the long-held view that there was limited capacity for southern Bangladesh to contribute to rabi-season production due to the high temperature environment and soil salinity. The ability to show that this was not the case was a major project outcome resulting in an increase in southern focus by government agencies encouraged by policy recommendations promoted or supported by the project. This was undertaken though the production of a number of publications supporting increased southern crop production targeting policy makers, other researchers, extension organisations and farmers.

Capacity

Farming systems capacity (intended)

The development of the capacity of the farming community and of the extension agencies to integrate wheat and mungbean into the farming system is the most important project outcome. This was obviously an intended component of project research and has been successfully achieved. This was done through research and extension, particularly the SMT program which was supported through the component research and simulation. Adoption would not have been achieved without increasing support at the policy level enabling extension agencies to promote the production of these crops widely in the south.

Development of simulation capability (intended)

Simulation modelling requires the availability of appropriate models, crop parameters and regional environmental data to ensure sensibility of results. The development of soil and long-term climate files enabled the analysis of the southern farming system to be undertaken using a number of models under the APSIM modelling framework including IRRI-ORYZA (later APSIM-ORYZA) and the wheat, mungbean and SWIM models. Because of the systems being modelled (ponded rice, capillary rise) the Bangladesh work then contributed back to improving modelling capability for use in Bangladesh and in other projects in Australia and internationally.

3. Adoption—how the project outputs are being used

Technical

Systems issues, varietal selection and on-farm research

Seasonal variability is increasingly impacting on farmer ability to flexibly manage crops. While farmer preference is to irrigate wheat and mungbean, this is becoming increasingly difficult due to a shortage of irrigation water resulting from diminishing and more seasonally variable rainfall. As a consequence, there has been a general move to rainfed cropping and if water is available, allocated to higher value crops such as vegetables. Farmers are also modifying the way that crops are used within the cropping system attempting to reduce the riskiness associated with climate variability. An example is the growing of rainfed mungbean as a single rabi-season crop. Project recommendations in 2011 advocated the double cropping of wheat (planted in November–December) and mungbean (planted March–April). However, while wheat production is continuing to increase, farmers are now spreading their risk by growing mungbean as a sole, short-duration (60 day) crop, planted in February when soil conditions are more conducive to good establishment, grown during a drier climatic period with lower pest pressures and maturing under more benign climatic conditions prior to early wet season rainfall.

The WRC pre-release wheat lines, BAW1059 and BAW1064 both showed good heat and salinity tolerance during regional screening and were released by the WRC in 2010 as Tista (BARI Gom 25) and Hashi (BARI Gom 26). These varieties have been adopted by farmers and now represent the majority of wheat grown in the south (final user). It is assumed that these varieties will continue to be used until disease impacts on their performance or more modern lines are released with preferred characteristics. Statistics from DAE for Barisal division show continuing increases in crop production over the period of interest. The area planted to wheat increased by 210% between 2011 and 2016 (from 4,543 to 14,091 ha) resulting in a 285% increase in production (from 9,217 to 35,458 t). These data reflect the increase in the number of Barisal wheat farmers from 56,469 households to 105,469 and the increase in average

yield from 2.0 to 2.5 t/ha. 2016 average yield and divisional production was lower than the preceding season due to a severe outbreak of the fungal disease, wheat blast, which affected around 16% of the national crop.

Total mungbean area in the Barisal division increased by 30% between 2011 and 2016 (from 104,200 to 136,833 ha) with production increasing by 66% (from 86,698 to 144,408 t). The number of farmer households growing mungbean increased by 30% from 662,096 in 2011 to 861,369 in 2016. Seasonal variability caused by variable planting conditions and limited access to irrigation resulted in variability in yield which ranged between 0.7 and 1.3 t/ha. Surveys indicated that while the farmer preference was to grow local mungbean varieties, the modern BARI Mung 6 was their actual choice because of its higher yield potential and returns and ease of harvesting.

Wheat production in Noakhali district remained stagnant during the period of interest with around 5–7% of farmers in the survey villages growing the crop in 2016 and overall district production only increasing from 17 to 165 ha between 2011 and 2016. Yields are lower and more variable than in Barisal due to soil salinity, a lack of irrigation and an increasingly variable climate. These resource poor farmers also indicated that access to seed of the modern varieties and equipment for planting and threshing were constraining increased production. As a result, farmers have moved to the production of higher value rabi-season rainfed crops with increases in soybean production (up by 52% from 2010), sweetpotato (up 82%), grass pea (up 211%), watermelon (up 57%) and winter vegetables (up 69%). Mungbean area remained reasonably stable between 2010 and 2015 with approximately 6,000 ha grown annually and 4,000–5,000 t of grain produced. Due to widespread rain damage to grass pea crops in 2017, mungbean area increased to 8,175 ha with production of 7,000 t.

Social and economic evaluation (intended)

DAE statistics discussed above provide evidence of the adoption of the technologies advocated by the project. This shows that the social requirements for adoption were met with systems interventions being profitable and knowledge and experience gained through project activities, particularly the SMT program. Recent surveys indicate that the adaptive capacity of farm households in survey villages has continued to increase over the past five years. Increased farm income and the education of family members has been a result of the increasing intensity of cropping, crop diversification, opportunities for off/non-farm wage work, extension support and ensured market demand and price of farm output, in particular for rabi crops.

Gross margin analysis in 2017 of individual rabi season crops in Barisal and Bhola districts showed that for a 250 decimal farm, at typical seasonal yield and average price, the highest gross margin was achieved by maize (Tk38, 672), followed by mungbean (Tk26,240), wheat (Tk21,252/ha), cowpea (Tk13,508/ha), grass pea (Tk12,959/ha) and by Boro rice (Tk11,120/ha). The poor gross margin for Boro rice was in part due to low yield, resulting from inadequate irrigation application and in part to high production costs and poor market price. In a poor season, mungbean produced the highest gross margin (Tk7,671/ha) due to the adoption of BARI Mung 6, followed by cowpea (Tk6,772/ha), grass pea (Tk4,803/ha), wheat (Tk838/ha) and Boro rice (-Tk6705/ha).

Policy (intended)

A major constraint to acceptance of research outcomes at the policy level was the long-held view that there was limited capacity for southern Bangladesh to contribute to rabi-season production due to the high temperature environment and soil salinity. The ability to show that this was not the case through continuing communication with senior researchers and extension managers and policy makers was a major project outcome resulting in an increase in southern focus by government agencies encouraged by policy recommendations promoted or supported by the project. Examples of this include, WRC, in collaboration with DAE continuing to demonstrate the use of the newly released wheat varieties, while the on-farm research, pulses and oilseed divisions of BARI, in collaboration with DAE, promote the use of BARI Mung 6. DAE have also undertaken a number of programs to increase cropping intensity in the south, including:

- the participatory crop choice initiative under the North West Crop Diversification project
- the rice/wheat/jute project
- pulses, oilseeds and onion strengthening project

- the Integrated Agricultural Productivity Project
- the Char Development and Settlement Programme.

It is expected that with positive southern crop production outcomes that support at the government level will continue.

Capacity

Farming systems (intended)

The development of the capacity of the farming community and of the extension agencies to integrate wheat and mungbean into the farming system is the most important project outcome. This was an intended component of project research and has been successfully achieved (final user) as shown by the number of farmers engaged, the areas under production and the increasing yields of wheat and mungbean over the past six years. This was achieved through a combination of component, on-farm and systems research with the SMT program being central to demonstration, seed supply and adoption. Adoption would not have been achieved without the increasing support at the policy level enabling extension and research agencies the continuing ability to support the production of these crops in the south.

Development of simulation capability (intended)

Simulation modelling requires the availability of appropriate models, crop parameters and environmental data to ensure sensibility of results for a particular geographic location.
The development of soil and climate databases for Bangladesh and contribution to the continuing development of both the APSIM-ORYZA and the wheat model enabled these tools to be used successfully in Bangladesh to explore the options and risks associated with the adoption of a series of annual season cropping scenarios. These included the prediction of crop yield for one or a series of crops in a rotational sequence, nitrogen balance, water balance in ponded rice and rabi-season crops where capillary rise contributed to water supply and the economics of production. While most models are always 'works in progress' and might be considered as never being complete, in terms of the Bangladesh simulations they can be considered as final user products. This is also the case for the developed databases which are now available for use by other modellers or for general agronomic use.

4. Impact—the difference the project will or may make

There are dramatic and continuing changes occurring in southern Bangladesh agricultural systems, which are resulting in a continuing improvement in farmer livelihoods. Increasing adoption and productivity of wheat and mungbean are part of overall systems improvement and should be seen as such, with impacts attributed to project research but also seen as part of much broader changes in southern agriculture.

The single most influential component of the project in terms of adoption and impact was the seed multiplication trial program to extend knowledge of modern varieties and good agronomic practice to both a geographically diverse farming community and within the government and non-government research and extension communities. The impact of this trial program can now be seen in the increases in farmer numbers and crop production that has occurred over the past six years. A real positive is that Bangladesh policy makers have seen the potential for the south to contribute to food security and are supporting continuing departmental initiatives.

The increased intensity of cropping in the Barisal division has significantly contributed to changes in the livelihoods of farm and non-farm families and overall communities. Food deficit households in the survey villages have become food secure and the most food secure families, food surplus. This indicates that subsistence families have transformed to semi-subsistence and to some extent commercial farming, in particular for rabi crops. About 85–90% of total producers in the surveyed villages now grow oilseeds and pulses, including mungbean, while 45–65% grow wheat, vegetables and potato as cash crops, with maize and soybean produced for commercial purposes.

In the villages of North Joynagar and Char Sefali on Bhola Island, mungbean area increased from 10–12% to 30–35% of total rabi cropping area between 2011 and 2016, while in Daxain Amtoly village in Borguna district, mungbean area increased from 15–20% to 50–60% over the same period. Across Barisal division, the number of households growing wheat varied by district with 3–5% of households in the survey villages of Patuakhali, Borguna and Jhalokhat now growing the crop where none was grown in 2011, while in Barisal district, 10–15% of households now grow wheat compared to 2–5% in 2011. Total income of farm families in Barisal increased by 20–35% between 2011 and 2016 due to the increased intensity of cropping, availability of seed for modern varieties, crop diversification, opportunities for off/non-farm wage work, extension supports and ensured market demand and price of farm production, particular rabi crops. Higher yielding wheat varieties have increased gross margin by 50–70% since 2011 contributing to this increase in family incomes (without calculation of effect of price inflation). This has resulted in improved wellbeing and adaptive capacity of whole coastal communities through an increased standard of living for both farm and non-farm families able to access to a more balanced and nutritious diet, better housing and consumer goods and increased education opportunities for children. These positive changes have impacted on non-farm families through increased local opportunities for wage workers, reducing the need for seasonal migration and an increased market for commodity traders, input sellers (fertiliser, pesticides, seed and machinery).

Despite the high yield potential of modern wheat varieties, crop area only increased from 17 to 165 ha across the Noakhali district between 2011 and 2016. While this is in part due to a lack of availability of wheat seed and a shortage of irrigation water, the main reason is the higher levels of soil salinity which reduce yield potential. In preference, farmers grow more profitable and better adapted crops including pulses and vegetables. 70–80% of farmers grow pulses, with mungbean dominant (30–35% of total rabi crops area), followed by grass pea (20–30%) and soybean (20–25%). Boro rice is extensively grown in areas with adequate access to irrigation. Total income of farm families in Noakhali increased by 20–30% between 2011 and 2016. This was due to the increased intensity of cropping, adoption of diversified high value cash crops (watermelon, vegetables, tomatoes, mungbean and soybean), availability of seed for modern varieties of pulses and vegetables, opportunities for off/non-farm wage work, extension support and increased access to the market in particular for rabi crops. Increased temporary overseas migration also contributed to increases in income and improve livelihood of farm families.

There has also been an improvement in environmental health with key informant farmers noting that the adoption of pulse crops had improved soil health, a result of nitrogen fixation and green manuring both of which have reduced the need for subsequent nitrogen fertiliser use.

In the longer term, it is considered that more farmers will continue to grow a range of crops and productivity will continue to increase in the south, however increases will always be dependent on climatic conditions, government policy and the economics of production which will undoubtedly change or fluctuate over time. While agricultural production will vary over time it is a positive project impact that the Bangladesh government and its agencies now recognise southern potential and its role in longer-term national food security, particularly in support of research and extension of crops appropriate to the region including wet season rice and the dry season crops of wheat, maize, sunflower, mungbean and vegetables.

Improving the profitability of village broiler production in PNG

Dr Geoff Kuehne, Meaningful Social Research

Project number	ASEM/2005/094
Project title	Improving the profitability of village broiler production in PNG
Collaborating institutions	National Agricultural Research Institute (NARI), Lutheran Development Service, Christian Leaders Training College, Ok Tedi Mining, PNG University of Technology
Project leader	Dr Phil Glatz, South Australian Research & Development Institute
Project duration	July 2007 to December 2012
Funding	A$928,016 total (ACIAR contribution A$639,834)
Countries involved	Papua New Guinea
Commodities involved	Poultry
Related projects	LPS/2001/077 Poultry feeding systems in PNG LPS/2003/054 Feeding village poultry in the Solomon Islands LPS/2006/149 Using local feeds to reduce the cost of pig and poultry production in Tonga

1. Motivation—what the project aimed to achieve

This research was motivated by the low profitability of village broiler farming caused by increasingly expensive feed brought about by an approximate doubling of costs of imported ingredients, the devaluation of the Kina, and rising cost of fuel for transport. Improving the profitability of village broiler farming through the use of locally available feedstuffs was also identified by National Agricultural Research Institute (NARI) as a high priority for the PNG livestock sector.

The relationship between NARI and South Australian Research & Development Institute (SARDI), with respect to this project, began in the mid 1990s when NARI approached SARDI for assistance regarding use of ecoshelters to house pigs and poultry in PNG. Following on from this, NARI approached ACIAR regarding research focused on reducing broiler feeding costs.

This project aimed to deliver more profitable feeding strategies to village farmers through the participation of non-government organisations (NGOs) and on-farm evaluation trials. The project also aimed to improve the profitability of smallholder broiler production in PNG by at least 25% and to increase smallholder broiler productivity by 5% per annum through greater use of lower-cost locally available feed resources. The achievements of the concentrate feeding system project were recognised by Technical Centre for Agricultural and Rural Cooperation who selected it as one of the top 20 agriculture innovations in African, Pacific and Caribbean countries (CTA, 2015).

2. Outputs—what the project produced

The major outputs of the project are described as follows.

- Low cost diets were formulated and evaluated in a series of on-station and on-farm broiler feeding trials. The diet identified with the greatest potential in the Western Highlands Province was equal parts of a low energy concentrate and sweetpotato; the diet best suited for lowland chicken meat production was equal parts of high energy concentrate and cassava while in the Western Province at Ok Tedi poultry grew equally well when fed with equal parts of a poultry concentrate and cassava or sweetpotato.
- An existing cassava mini-mill, which was located at Domil Community, was used for training in how to mix concentrate diets. The first commercial concentrate diets were manufactured and sold to village broiler farmers.
- Various extension and resource materials were produced.
  - **Fact sheets**: draft one-page information leaflets on best practice feeding methods for village poultry were developed by SARDI and NARI. The leaflets show pictures of the feed ingredients, how they are prepared, the amount of local sweetpotato or cassava to include in the diet and how the diet is fed to birds.
  - **Newsletters**: newsletters from NARI (Didinet News) were disseminated to partners with a focus on outputs from the project. Poultry handouts provided basic management advice for interested farmers and were also given to students.
  - **Radio**: many village farmers maintain regular contact with NGOs via extension visits and via advice given by officers on local radio. Training information was also provided to farmers over the radio.
  - **Handbooks**: NARI and the NGOs distributed various handbooks and farmers' booklets. Information generated from various poultry projects were included for distribution to village farmer networks.
  - **Video production**: a video was produced with a village farmer being shown how to feed broilers in the traditional manner using commercial feed. An extension officer was shown visiting the village farmer with a bag of concentrate. The officer shows the farmer how to cook local vegetables and mix it in with a concentrate. The audience for the video was the village farmers in PNG and other Pacific Islands.
  - **Poultry production curriculum** for Unitech, Christian Leaders Training College (CLTC) and Lutheran Development Service (LDS): fact sheets for local feed ingredients in PNG were developed by SARDI and made available to partners to include in the curriculum. The fact sheets contained the name, general description, chemical composition, nutritive value and anti-nutritional factors for each ingredient. The fact sheets also provided guidelines on the use of ingredients in poultry diets. This information was obtained from journals, books, Internet and feed ingredient tables.
- Economic models were developed to determine the cost of locally-milled broiler concentrate compared with the price of the commercially available alternative at several key sites in PNG. Spreadsheets of the cost of producing concentrate feed from mini-mills and profitability of village broiler grow-out operations were developed to assist with economic assessment. This led to ACIAR supporting the development of the follow-up project *Enhancing role of small scale feed milling in the development of the monogastric industries in Papua New Guinea*.
- Infrastructure to conduct on-station grow-out trials were developed at LDS in lowlands, CLTC in the highlands and at Ok Tedi in the Western Province, including protocols and training for the conduct of trials. Demonstration facilities were also established at numerous village farms in the highland and lowlands.

These major outputs were mostly technical but each of them had a capacity building component, for the research staff, the NGOs staff and the farmers who were involved.

The chief new knowledge for researchers was the finding that broiler chickens could be raised at lower cost using diets formulated from locally available feed resources. This was made possible by an increased knowledge of feed formulation, milling, and blending techniques. Researchers also gained a better understanding of how to design on-station and on-farm boiler feeding trials, nutritional values of local and commercial feed ingredients and how they contributed to growth and

production performance of broilers and layers. For NARI staff this project also led to new knowledge about working with farmer networks and delivering farmer training. It increased their understanding of farmers and improved their ability to communicate with them. Researchers who were not directly involved in the project also gained new knowledge, either directly from those involved in the project, or indirectly through the extension materials such as flyers, fact sheets and other publications that was generated by the project.

The partners and collaborators who were involved in the project formed networks and linkages or further strengthened their existing networks and linkages. These included the establishment of World Poultry Science Association Branch in PNG with membership from NARI, University of Technology, Lae Feed Mills, Nui Guinea Tablebirds, Christian Leaders Training College, as well as other organisations in PNG.

Capacity was improved at NARI, Unitech and partner NGOs as they increased their ability to conduct effective research and form linkages with partners and stakeholders. The success of the broiler project led to the securing of additional funds from ACIAR, European Union, CTA and from the PNG government to extend the research to layers and the introduction of mini mills.

Farmer's capacity was also built because they started to understand more about their local feeds and how they could be used as part of a feed ration.

3. Adoption—how the project outputs are being used

- Low cost diets using local feed resources were formulated. This was not able to be adopted in the way intended by the final user (the smallholder farmer) because of the unavailability of the concentrate. The availability of the concentrate relied on the next user adopting it. It is possible that the potential next users, because they were not as involved in the project as the partners, were not fully aware of the significance of their position and the impact that their decisions had on the final user. Except in a few cases, such as the Domil community, the level of adoption remains low because of restricted access to the concentrate. If convenient access to concentrate was made available the level of adoption would be likely to rise. There is some evidence that farmers' mix sweetpotato or cassava with normal broiler feed is a second-best option. A survey is needed to evaluate the feeding options now in place on village farms.
- A mini-mill was located at Domil Community, training to mix concentrate diets conducted and first commercial concentrate diets were manufactured and sold to village broiler farmers. The business model for the Domil mill established that the savings in feed costs were 12% compared to using commercial feed. This information was disseminated and able to be used by the end users. The Domil community has successfully adopted the broiler feeding technology.

Factors affecting the adoption of project outputs were:

- the availability of the NARI-developed concentrate, which was reliant on commercial mills mixing the concentrate
- capital constraints for small to medium-size enterprises and infrastructure constraints for larger-scale broiler feeding operations that were required to have better housing, slaughter and refrigeration facilities
- rapid social and cultural change as communities move away from traditional beliefs and practices due to Western influences, although some thought the changes were welcomed by community members
- awareness of the technology (although some thought that adoption would spread regardless). Awareness of the broiler feeding technology was expected to encourage adoption but it appears that often farmers who had adopted the broiler feeding practice avoided letting others know of their activities due to the high levels of theft in PNG. The potential for theft of chickens discouraged adoption
- farmers lacking a business-oriented approach—PNG's traditional Wantok still has a strong influence across society and in many cases discourages entrepreneurial activity
- high transport costs for some farmers to access markets made broiler raising less profitable and therefore adoption less likely

- farmers' need to raise money for a specific purpose, such as school fees, influenced whether adoption would be ongoing or whether it would be erratic and opportunistic
- the labour required to grow local feed resources, which potentially made the purchase of commercial feed a more attractive option than mixing local feed resources with concentrate.

4. Impact—the difference the project will or may make

The project has contributed to improvements in the local communities in a number of different ways.

- Trade has been encouraged as farmers raising broilers needed to seek out other sources of sweetpotato and cassava. The beneficial social impacts from needing to cooperate with, and rely upon, people other than family or clan members has been reduced tribal conflict and its associated violence.
- Greater efficiencies in broiler feeding activities have been gained from specialisation, which has led to reduced labour demands for the broiler farmer.
- Reduced feed costs have led to increased income for broiler farmers. When the trial was active farmers were able to use the extra income for purchases such as steel roofs for their houses which led to health benefits.
- The regimented feeding of animals required them to be caged or penned. This enabled the use of poultry manure as a fertiliser. It also had a positive impact on the cleanliness of the village environs and water supply, leading to additional health benefits.
- The added demand for local broiler feed created a new market for cassava which previously was underutilised. It offered villagers similar returns to growing coffee but with less effort.
- New business and employment opportunities have been created, which was especially important for the more remote communities.
- The project has contributed to a substantial social impact on communities, for example the Domil community video.

The range of demonstrated impacts indicate the substantial impacts that this project could have if the important constraints were removed and it was to be more widely adopted.

The most important factor constraining the project's success has been the availability of concentrate. The early part of the project demonstrated that people were happy with the project outcomes and it seems that had the concentrate remained available the initial users they would have continued using it leading to more widespread adoption over time. This project has the potential to deliver substantial positive impacts that spread further than the farmers involved. This does depend on the concentrate being made available again through the actions of NARI, an NGO, or an entrepreneur. If this was to occur the first impacts are likely to felt very soon after the farmers begin using the concentrate again. Due to the diverse nature of the impacts that come from this project they are likely to build and potentially become self-sustaining rather than quickly plateau.

There were no clearly identifiable negative impacts from this project.

Reference

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Scaling-up herd management strategies in crop–livestock systems in Lombok

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Project number	SMAR/2006/096
Project title	Scaling-up herd management strategies in crop-livestock systems in Lombok
Collaborating institutions	Universitas Mataram; Balai Pengkajian Teknologi Pertanian - Nusa Tenggara Barat; Dinas Peternakan - Nusa Tenggara Barat; CSIRO Australia
Project leaders	Dr Bruce Pengelly, CSIRO Dr Ketut Puspadi, Balai Pengkajian Teknologi Pertanian
Project duration	June 2007 to June 2012
Funding	A$1,377,484 total (ACIAR contribution A$1,102,976)
Countries involved	Indonesia (Lombok); Australia
Commodities involved	Livestock, rice, forage
Related projects	SMAR/2006/061 Building capacity in the knowledge and adoption of Bali cattle improvement technology in South Sulawesi LPS/2004/005 Improving smallholder crop-livestock systems in eastern Indonesia AS2/2000/103 Developing an integrated production system for Bali cattle in the eastern islands of Indonesia AS2/2000/124 Prospects for improved integration of high quality forages in the crop-livestock systems of Sulawesi, Indonesia AS2/2000/125 Optimising crop-livestock systems in West Nusa Tenggara Province, Indonesia

1. Motivation—what the project aimed to achieve

The Lombok livestock project was developed to support the Indonesian Government's goals of increasing self-sufficiency in beef production and boosting economic development of its poorest regions.

On Lombok Island in West Nusa Tenggara Province (NTB), cattle production is predominantly small-scale (2–4 cattle per household) and intensive, with cattle often reared in communal structures, called kandangs. There is little or no access to free grazing of pasture or crop residues. Key constraints to improving cattle productivity include scarcity of quality feed, sub-optimal animal husbandry practices resulting in low reproduction rates, poor waste management and limited resources of smallholder farmers to make changes to their farming enterprise.

There are at least 800 communal kandangs in operation on Lombok. They are readily used in areas where cattle density is high and land availability for grazing and forage is low, such as in central Lombok. The communal system presented an opportunity for the project to redress productivity constraints associated with breeding, feeding and hygiene.

The project was one of a suite of ACIAR-funded projects on beef production and markets in eastern Indonesia. The projects loosely fall into three phases:

1. understanding the farming system, including smallholder constraints and priorities, to identify and pilot interventions for breeding and feeding management of Bali cattle
2. testing and tailoring 'best bet' options with farmers and extension workers
3. supporting dissemination and adoption through capacity building and institutional engagement.

Where feasible, the project used common demonstration or study sites and throughout the series, partnerships and trust were built between research agencies, government agencies and farming communities. In this project, the formal partners were University of Mataram (UNRAM), Balai Pengkajian Teknologi Pertanian (BPTP) of NTB, CSIRO and Dinas Peternakan (Department of Livestock Services).

Anticipated outcomes of the project included a lasting improvement to cattle production in Lombok, improved capacity in institutions and communities to support uptake of practices and knowledge and widely applicable approaches to adoption. While improved household welfare was a measurable objective, the project had no specific livelihood targets.

2. Outputs—what the project produced

The adoption study focused on six key project outputs:

- two technical
- one amalgamated policy
- capacity development of three stakeholder groups.

These outputs were selected as they were uniquely attributable to the SMAR/2006/096 project, rather than outputs of the suite of livestock projects related to this project.

Technical outputs

Implementation of management practices in project kandangs

The 'technology package' is a set of practices that was intended to support cattle management in communal kandangs. The package was developed to maximise reproductive potential and convert this to greater turn-off and increased sales without overt strain on limited resources, such as land for forage and space to house new animals.

The practices are not unique to the Lombok project, having their origins and initial testing in previous ACIAR projects. However, the scale of implementation to 36 kandangs in Central Lombok and the participatory testing of practices in those kandangs was novel.

The intention of the project was not broad-scale dissemination of practices but testing the model with participating farmers, with the goal of proving the benefits of the model for institutional uptake, thereby expanding the benefits more broadly.

Enhanced understanding of adoption processes

A technical research output of the project was an enhanced understanding of adoption processes, particularly how farmers make decisions around and spread information about new agricultural practices.

Despite the large body of research in cattle management in this region, this was the first ACIAR-funded project to engage social science capability to explore adoption and dissemination relating to cattle management as a research question.

Policy outputs

Influence on local institutions to support uptake of practices

Policy outputs can be defined in terms of a number of strategic and structured stakeholder engagement mechanisms, and sustained networking and collaboration.

The intention of the project's stakeholder engagement was to influence relevant policies and programs towards uptake of beneficial approaches to cattle productivity and to foster sustainability of the project approach and capacity by embedding them in local government systems.

Institutional uptake of practices was an explicit objective of the project.

Capacity developed

Improved capacity to support uptake of practices: on ground team (OGT)

It was anticipated that the project would equip the On Ground Team (a group of graduates with responsibility for technical advice and engagement with farmers) with a set of highly transferable skills, experience and contacts that would be valuable beyond the project and that would potentially become a capacity foundation for farmer engagement in livestock agencies in NTB.

Employing and building capacity of the OGT was a primary objective of the project.

Improved capacity to support uptake of practices: project specialist team (PST)

The PST was responsible for designing and overseeing the research aspects of the project and for providing technical support and training to the OGT. All members of the PST had used their specific expertise in development projects previously, but the combination of intensive engagement, participatory approach and inclusion of OGT was new.

The PST hold ownership of the project approach and while improved capacity in the PST was not a primary objective of the project, it was anticipated that members may have used principles and practices in other projects and fora.

Improved capacity to support uptake of practices: farming community

Community level adoption and impact relies on enhancing the capacity of farmers to understand, implement and adjust project practices that might be beneficial to their farm enterprise.

Farmer skills and knowledge were built by the OGT and PST, through the participatory nature of the project to introduce, test and assess the new practices. Improving the technical capacity of farmers was a primary objective of the project.

3. Adoption—how the project outputs are being used

Adoption of technical outputs

Adoption of project practices towards the end of the project (2009) and six years later (2015) is summarised in Table 5.

Table 5: Adoption of project practices by farmers in participating farmer groups, comparing 2009 project data (van Wensveen et al 2017) and 2015 post-project data (Dahlanuddin, unpublished).

Project practice	2009 adoption (n=785 farmers[a])	2015 adoption (n=928 farmers[c])
Using quality bulls for natural mating	100%	82%
Mating cows at 40–60 days after calving	70%	56%
Weaning calves at 6 months	56%	23%
Preferentially feeding pregnant and lactating cows	52%	53%
Planting and using improved forages	39% grew new forage; 51% expanded existing forage[b]	92%

[a] Only data from the first 24 farmer groups (n=785 farmers) are included as the last 12 groups (n=359 farmers) had only been participating in the project for six months at the time of data collection

[b] These figures are not mutually exclusive

[c] Calculation excludes three farmer groups that have ceased to function since the end of the project.

The project occurred in the context of resource limitations faced by farmers and a key contributor to its success was its ability to address some of these resource limitations. The practices promoted by the project were built on existing knowledge and infrastructure and further developing how these resources were perceived and used. This made adoption of practices more accessible for many project households.

A key mechanism for participating farmer uptake was to visit more established project groups, thereby providing evidence of what could be achieved in a realistic (i.e. on-farm) setting. Social network analyses suggest that key institutions for the spread of project information (beyond interaction with the OGT) were the mosque, family networks, use of the bull service, and through communal activities such as forage collection.

Between 400 and 500 satellite farmers took up at least one of the practices during the project, predominantly bull services from a nearby kandang. These farmers generally received less information about the value of project practices and how to implement them and this deterred adoption for many farmers not in regular communication with project groups (e.g. through proximity or family connections).

By 2015, fewer farmers were using a dedicated, quality bull for mating, although the rate of use was still high. Interviews undertaken in this adoption study suggest this may be due to:

- a high prevalence of artificial insemination being used to produce larger crossbreed calves that fetch a higher price at sale
- the use of a bull owned by one of the group members, rather than a communally managed bull
- the perceived high transaction cost of maintaining a bull and/or the micro-finance system to support it.

While this can be perceived as effective adaptation, potential disadvantages include: lower quality genetic stock and increased likelihood of inbreeding, physiological problems for cows producing large crossbreed calves and dilution of NTB's Bali cattle breeding stock.

Fewer farmers overall were mating cows 40–60 days after calving and implementing early weaning. Reasons include the discontinuation of recording breeding information by some groups, unease at separating cows and calves and lack of space to separate cows and calves. Rates of preferential feeding remained stable, with practicing farmers claiming that their cows and calves are healthier, well nourished and in better condition.

Availability of land remains a constraint for forage production in the study area. However, almost all farmers in the 2015 study continued to plant and use improved forage and interviews revealed that the area for forage increased (e.g. on rice bunds and in unused land) by necessity as the area available for grazing continues to decrease.

Satellite farmers interviewed in the adoption study demonstrated a nuanced understanding of the farming system and had adapted project practices accordingly. For example, one farmer group used recorded information on calving interval and available forage supply as a guide to mating, rather than the recommended June to December period.

There is limited evidence that the findings of the adoption research have had broader influence, for example, by informing research activities within the project, or by informing other research and extension activities since the project.

Adoption of policy outputs

The project was able to demonstrate significant contribution to, and influence on key policies and programs at provincial and district levels at the end of the project. The formal mechanism for this was the Program Advisory Committee (PAC), which met regularly during the project, bringing together key stakeholders from the provincial and district level Dinas Peternakan, Regional Body for Planning and Development (BAPPEDA), cattle traders, BPTP, UNRAM and CSIRO. While this created awareness and discussion with key leaders about the project, informal networking, meetings and relationship building by the Indonesian project leader and coordinator are likely to have been what turned support in meetings into tangible outcomes.

Significant achievements arising from the project include:

- shaping the NTB program to become the 'Land of a Million Cattle' (Bumi Sejuta Sapi or BSS), through participation on the Governor's Taskforce and the development of a Blueprint Strategy for meeting the BSS objectives
- motivating Dinas Peternakan to include provision of bulls for mating as part of their program
- creation of Governor Decrees on Bali Cattle Breeding and Grading and Price Incentives as part of the subsequent ANTARA initiative that used this project as a basis for addressing market transparency issues.

Estimating the actual number of farmers reached through policy mechanisms is beyond the scope and resources of this adoption study. However, three additional areas of influence were identified:

- a 2013 Dinas Peternakan program supporting improved breeding stock
- continuation of methods of recording and monitoring breeding information and calf growth rates by Dinas Peternakan
- the influence on Dinas Peternakan staff that has arisen from the employment of three of the project's OGT.

Capacity utilisation

Reflecting at the end of the project, the project team felt that capacity building and experience from project activities provided an excellent foundation for OGT members as knowledge brokers, with the OGT as both keepers and deliverers of relevant information and expertise.

In February 2017, seven OGT members were employed by the government, one was employed by the private sector, one by an NGO, one by a philanthropic organisation and one by the University of Mataram, contributing to a number of subsequent ACIAR projects.

Four of the OGT are currently working in livestock-related roles, including three now employed by Dinas Peternakan Propinsi. These OGT members reported that the skills and knowledge developed in the project were brought into their current roles include:

- selection and facilitation of farmer groups
- analysing and solving problems with farmers
- using a systems approach for finding farm management solutions
- application of project cattle management practices.

Those not working in livestock roles state that they use the networking, relationship and facilitation skills they learned in the project, along with techniques of data collection and monitoring and use of pilot villages or groups as demonstration and learning sites.

The importance of the OGT to the success of the project was acknowledged by relevant livestock and extension agencies during the project and in the adoption study. However, the 'OGT model' of employing, training and mentoring dedicated knowledge brokers has not been adopted/adapted into Indonesian government agencies. The PST noted that operating models of the agencies are so different that this would require systemic change or restructure, which is unlikely. The OGT model has been used in several subsequent ACIAR and DFAT-funded projects in NTB, Timor Leste and Vietnam.

Improved capacity outcomes for the Lombok PST include:

- UNRAM Faculty of Livestock Studies using a more practical and applied approach to teaching than it did before the project
- interactions with farmer groups challenging theoretical understanding with practical experience
- enhancing the professional reputation of PST members, resulting in easier networking for new initiatives and recognition as experts on livestock productivity and international collaboration.

At the end of the project, participating farmer groups stated that engagement with the project had not only increased their skills and knowledge of improved livestock management practices, but also the social capital of the group, through increased cohesion, communication and cooperation.

The project team (PST and OGT) observed significant changes in technical skills and knowledge of farmer groups during the project, and also the emergence of a deeper understanding of causal links between practice and benefit, and enhanced problem solving skills in the farmer groups. In addition they noted increased confidence, greater awareness of economic opportunity, increased communication and cooperation and more efficient use of communal resources as significant changes.

While farmers interviewed in the adoption study valued the support of the OGT, most were confident with the skills and knowledge they gained from the project and are still applying (and in some case modifying) them in their farm enterprise to continued benefit. Several suggested they faced no significant challenges because the practices were easy and inexpensive to implement.

All project groups interviewed in the adoption study continued to host visits from outside farmers who were interested in the benefits of the project practices. They suggest that these farmers are implementing some or all practices, with successful results. Satellite farmers interviewed for the adoption study were both implementing and modifying the project practices to address specific resource constraints.

Adoption in the future

Based on widely accepted normative distribution for adoption within a population, Martin (2010) estimated five percent adoption of project practices, or around 11,000 Lombok farmers by 2020, assuming limited public extension support.

It is appropriate to anticipate continued adoption of practices by participating groups and their satellites. With evidence of continued interest by other farmers, and a continued willingness by former project groups to promote and support others to learn about the practices, it is likewise reasonable to consider that adoption will occur beyond these groups in line with Martin's initial assessment. However it seems unlikely that adoption will reach Martin's projected 11,000 farmers.

The aim of the project was not to scale-out project practices but to test a model that could be adopted by government agencies for further scale out. This had not happened as anticipated by the end of the project. Factors limiting continued uptake and expansion include:

- current import and beef pricing policies that apply downward pressure on prices, disadvantaging smallholders
- programs for crossbreeding and artificial insemination that undermine farmer adoption of controlled natural mating with a quality bull
- limits to expansion based on the extent of local champion networks and proximity to successful project farmer groups.

Since the end of the project, there have been no formal mechanisms to influence policy or local institutions. However, PST members continue to engage with key departments and decision makers through a series of related projects that build on the project's work, and which have a strong focus on engaging with policy development and livestock services from local to national scales.

There was no indication from policy stakeholders interviewed that current programs incorporating aspects of the project would be stopped, but continued implementation is contingent on a range of policy dynamics, government prioritisation and resourcing.

Factors affecting adoption

The technology package promoted by the project had a number of general features that are well known to support adoption:

- practices are relatively easy to apply
- they build on existing social institutions and practices
- address key constraints and farmer needs
- have clear benefits even when only selected practices are adopted
- demonstrate clear benefits that are readily observable.

More complex practices that rely on group decision making and management of resources, have been harder to adopt or sustain post-project.

The practices have relevance and are applicable across a wide range of Indonesian farming systems. However, management and governance arrangements developed under the Lombok project are particularly suited to the communally-managed kandangs of Central Lombok. Different systems and processes would be needed in areas of NTB with extensive cattle production systems, such as Sumbawa.

Underpinning the success of adoption at the farmer group level has been the OGT (mentored by the PST), who supported farmer learning and built farmer confidence to apply and adapt the practices. The conclusion of project support for the OGT, and the perception by key agencies that they are unable (through lack of financial and human resource) to pursue a similar model has been a key factor limiting expansion.

The project demonstrated clear alignment with central and provincial government priorities and the PST played a pivotal role in capitalising on opportunities for policy influence. Establishment of the PAC promoted visibility, credibility and relevance, and the informal engagement and networks of the Indonesian team allowed project knowledge to be embedded in key policy activities. The degree to which this engagement has been translated into influence was limited by factors such as:

- partial adoption of project recommendations (e.g. provision of a bull without the means to sustainably manage it) has limited overall effectiveness and empowerment
- competing priorities of relevant central and provincial agencies limits autonomy to apply locally relevant approaches
- structure, incentives and resourcing in relevant agencies are significant constraints to adoption of successful extension approaches such as the OGT model
- the complexity of Indonesian policy and program development (and finite capacity to engage) limited more widespread application of project practices and approaches, although significant provincial influence was achieved in the project's three years.

4. Impact—the difference the project will or may make

Early in the project, the Lombok team developed a slogan for the project's aspiration and approach: *satu induk, satu anak, satu tahun* (3S), or *one cow, one calf, one year*. This encompassed the objectives to shorten the inter-calving interval (by controlled mating), increase productivity (through better nutrition) and decrease calf mortality (through health and nutrition).

Table 6 shows that the uptake of project practices resulted in significant increases in productivity and calf health, with the 3S aim almost realised in a period of around two and a half years.

Table 6: Comparison of selected calving indicators from baseline data for central Lombok and project results to mid-2010 for the first and second set of kandang groups (n=23).

Indicator	Baseline data	Regional government target (2010)	Project average (2010)
Calving rate (%)	52 [a]	85	86.7
Calf mortality (%)	15 [a]	10	6.2
Birth weight (kg)	12.7 [a]	n/a	16.0
Weaning weight (kg) 6–7 months	70 [b]	n/a	90.2
Daily weight gain between birth and weaning (kg/day)	0.25 [b]	n/a	0.35
Calving interval (months)	16 [b]	14	12.4

[a] A Talib et al's (2003) data is based on national and regional statistics, research data and information from government and university officers and regional farming groups;

[b] ACIAR Project AS2/2000/103

While the herd size across project groups remained relatively stable for the duration of the project, births and sales increased. Farmers were able to sell animals at a younger age because the weight gain between birth and weaning increased. Hence a market-ready animal required fewer inputs for the same financial outcome.

In this way, resource-constrained farmers were realising their objective of increasing reproductive potential and converting this to greater turn-off, rather than increasing herd size. This poses a challenge for regional government initiatives to increase NTB's breeding herd. Unless more land becomes available for forage production, herd numbers are unlikely to increase, even though increased throughput is benefiting farmers.

A comparison of production before and after introduction of project activities (using the Integrated Analysis Tool for the project's Final Report) suggested that an increase in beef production of 155% and farmer revenue of 175% was possible for a kandang of 100 cows over five years. While it was not possible to collect these data in the adoption study, farmers interviewed as part of the adoption study confirmed earlier findings that ongoing use of project practices has produced healthier animals which has supported increased income from cattle sales, through either more sales or higher prices they were able to negotiate for animals in better condition.

In addition to increased productivity and income, there is evidence of impact on labour allocation and, land use, although the extent of these impacts varies between farmer groups. Farmer interviews also indicated the impact of adoption had changed how farmers saw the position of cattle in their livelihood portfolio, with a shift towards increased importance of cattle.

The farmers interviewed at the end of the project, and during the adoption study reported that the improved condition of their animals meant they were able to fetch higher prices at market. A key focus of the ANTARA project was to formalise a system to secure higher prices for better quality animals. Though this was decreed by the governor, in reality the minimum price is not maintained.

Furthermore, the Indonesian Government introduced policies in 2016 to reduce the price of beef for consumers, such as allowing imports of boxed meat from India and setting a goal for beef to be sold at or under Rp 80,000 per kilogram.

Though farmers can still receive significant financial benefit from adoption of project practices that result in shortened calving interval, the broader policy and price context sets perverse incentives (e.g. for larger crossbreeds less adapted to local conditions) and has undermined efforts to establish greater transparency and farmer empowerment in market transactions.

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