ADOPTION OF ACIAR PROJECT OUTPUTS

STUDIES OF PROJECTS COMPLETED IN

2003–2004

Australian Government

Australian Centre for
International Agricultural Research

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Editors: David Pearce and Jeff Davis

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The Australian Centre for International Agricultural Research (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.

ACIAR seeks to ensure that the outputs of its funded research are adopted by farmers, policymakers, quarantine officers and other intended beneficiaries. As part of its efforts to monitor the outputs and outcomes of its projects, ACIAR has commissioned project leaders and participants to revisit projects 3 to 4 years after completion, and report back to ACIAR on the medium-term outcomes of the work. This series reports the results of these studies.

Communications regarding any aspects of this series should be directed to:

The Research Program Manager
Policy Linkages and Impact Assessment Program
ACIAR
GPO Box 1571
Canberra ACT 2601
Australia

Phone +61 2 6217 0500
Email aciar@aciar.gov.au

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aciar@aciar.gov.au

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Foreword

The Australian Centre for International Agricultural Research (ACIAR) has a funding base of about A$60 million and invests in agricultural research projects that contribute to poverty alleviation.

One of the challenges facing ACIAR and its partner scientists is to ensure that projects leave a legacy that continues to benefit the partner countries and communities well after the projects themselves are completed.

It is not good enough for projects to be delivering benefits only while donor funds are provided. Successful projects impart knowledge and skills, and leave in place technology that is sustainable under local conditions.

Formal independent project impact assessments have always been an important part of ACIAR's accountability process and means of improving project selection and management. The adoption studies that form the body of this report are an important intermediate stage between completion of the projects and these rigorous, independent impact assessment studies.

The studies are undertaken 3–4 years after each project is completed to assess the level of uptake and the legacy of the project. They provide valuable insights into the uptake of project results and the impact on local communities, and form a basis for the impact assessments.

This is the fifth year these adoption studies have been undertaken. We now have a portfolio of studies for 49 sets of projects, so we are able to learn important lessons from them. The process for undertaking these studies has now been integrated with the impact assessment studies so there is consistency between them.

I particularly want to thank the Australian project participants who revisited their partner-country collaborators to gather and collate data and write the adoption statements that form the basis of this publication.

I also want to thank the many project participants in our partner countries who hosted these visits, helped with data gathering and provided useful insights on the ongoing impact and effectiveness of these projects. My sincere thanks to each of you for your support in what ACIAR believes is a very important activity.

Peter Core
Chief Executive Officer
Australian Centre for International Agricultural Research

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Overview

David Pearce

Introduction

As for previous reports in ACIAR's adoption studies series, the 11 projects presented here continue to demonstrate the diversity of the ACIAR portfolio. The projects reported here cover six individual partner countries (China—three projects, Fiji—one project, India—three projects, Indonesia—one project, PNG—one project and Vietnam—three projects) and one major regional grouping (Central Asian republics and Caucasus —1 project). They also cover seven products (beef cattle, fish, maize, peanuts, rice, shrimp and wool) as well as two projects covering combined major commodity groups.

These studies illustrate the fact that agricultural research in its broadest sense can be focused on many points in the production chain. Sometimes this is providing information for researchers themselves (as in the plant genetic resource project) while at the other end it may involve specific techniques for processors (as in the Chinese and Indian wool-processing projects) or information for policymakers to influence the development of an industry (as in the barramundi fishery project, for example). In between, techniques suitable for immediate dissemination to farmers may be developed (as in the rice–shrimp farming project).

The adoption studies presented here describe the intentions and the outcomes of 11 projects completed in 2003–04. They contain useful information on what works and what doesn't, and on the factors that help adoption and those that hinder it. This overview provides a summary of the project outputs, their effects in terms of capacity building and the lessons for adoption that may be useful in the future.

Of the 11 projects presented here, the majority were focused on providing new technologies or practical approaches to assist processors, breeders or farmers increase their effectiveness—although in most cases some scientific knowledge was also gained. Two of the projects were focused on policy issues, with one being highly successful and the other achieving very limited success.

Overall, just under half (five) of the projects achieved a very high level of adoption, two achieved a medium level of adoption, two experienced low adoption and the remaining two had no adoption. The levels of adoption are explained in more detail below.

Project outputs

As noted in previous adoption studies, ACIAR-funded projects have three broad categories of output:

- new technologies or practical approaches to dealing with particular problems or issues
- new scientific knowledge or basic understanding (pure or basic science) of the phenomena or social institutions that affect agriculture
- the development of knowledge, models and frameworks to aid policymakers or broad-level decision-making.

There is, of course, potential overlap between these categories, and many projects contribute to more than one of them. Projects also target a variety of different elements in the overall production chain. Table 1 summarises the nature of the outputs for the 11 projects covered in this report.

New technologies or practical approaches feature highly as major outputs in these projects, in many cases involving the processing or storage stage of production, rather than activities at the farm level. While scientific knowledge did emerge from several projects, this was generally not a major output. Knowledge for policy featured in two projects.

Table 1. Project outputs

Project	New technology/practical approaches	Scientific knowledge	Knowledge, models for policy
Determinants of food choice in Fiji and their role in demand trends for high nutritional valued foods and nutrition security	Improved understanding of survey techniques —targeted at policy researchers	Understanding of food choices in Fiji—targeted at policymakers	Food choice model for policy analysis—targeted at policymakers
Treatment of wool-scouring effluents in Australia, China and India	Technologies and systems for optimising wool-scouring processes and effluent treatment—targeted at processors		
Development of specification and processing prediction techniques for the Chinese and Indian wool industries	Techniques to improve yarn quality and spinning performance in Chinese and Indian wool mills including the Yarnspec model—targeted at processors		

Table 1. (continued)

Project	New technology/practical approaches	Scientific knowledge	Knowledge, models for policy
Leucaena management in West Timor and Cape York	Identification of a superior feed hybrid for feeding cattle—targeted at farmers Adoption of known profitable farming system more broadly—targeted at farmers	General knowledge on limitations and opportunities for enhanced cattle production in Timor—targeted at a broad policy level	
An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta	Identified rice variety for salinised fields—farmers Techniques for shrimp management—farmers	Management practices to ensure environmental and economic sustainability of rice–shrimp farming	
Conservation, evaluation and utilisation of plant genetic resources from the Central Asian republics and Caucasus	Germplasm for use in plant breeding targeted at plant breeders	Material for Australian genetic resource centres	Improved relations with international organisations
Bioherbicide development for cereals in integrated weed management	Attempt to find effective fungal pathogens for wheat and rice	Knowledge that this approach is not successful in actual use	
More efficient breeding of drought-resistant peanuts in India and Australia	New breeding approaches—targeted at breeders Promising varieties released—to farmers	Knowledge of the physiological basis of crop performance under drought	
The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea		Biology of barramundi fisheries Importance of barramundi to local economies	Barramundi Fisheries Management Plan Bioeconomic model
In-store drying of grain in China	Technology transfer of in-store drying and storage facilities	Adaptation of technology to Chinese conditions	
Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia	Rapid diagnostic tests Improved tests and procedures		

Capacity development

As well as the specific output intended for the research, by bringing together diverse groups of researchers and by connecting Australian and partner-country practitioners, ACIAR-funded projects can lead to the development of increased capacity (to do research, to apply research techniques or to understand policy issues) amongst partner-country researchers and decision-makers. ACIAR funding may also create research infrastructure that may generate returns from future use. Table 2 summarises the kinds of capacity developed in the projects covered in this report.

Many of the projects involved formal training of partner-country researchers; others involved obtaining higher academic qualifications. In some cases, research infrastructure was provided, or new techniques were transferred to researchers in partner countries.

Capacity building was sometimes an explicit and essential part of the technology transfer from the project. In other cases it was the side effect of undertaking research for the project. In most cases, this increased capacity has continued to be used within similar areas of research in the partner country, sometimes with trained researchers being promoted to positions of greater responsibility in partner-country organisations and continuing to work in areas similar to those of the original project.

Two of the adoption reports noted that the encouragement of collaboration between Australian and partner-country researchers and the establishment of productive networks of exchange was in fact a major output of the projects. This was identified as a unique feature of ACIAR-funded projects.

Table 2. Research capacity built by the projects

Project	Partner-country/ies researchers	Research infrastructure	Capacity utilised
An investigation of the determinants of food choice in Fiji and their role in demand trends for high nutritional valued foods and nutrition security	Survey training improved the capacity and skills of staff at the National Food and Nutrition Centre	A 'food choice model' made available	The food choice model has not been used
The treatment of wool-scouring effluents in Australia, China and India	Research personnel in China and India trained in laboratory techniques for analysis of wool and effluent		Ongoing
Development of specification and processing prediction techniques for the Chinese and Indian wool industries	Enhanced linkage between industry and university teaching by introducing process prediction and quality control into the syllabus		Ongoing

Table 2. (continued)

Project	Partner-country/ies researchers	Research infrastructure	Capacity utilised
Leucaena management in West Timor and Cape York	Training of university staff		Those trained remained researchers within the field
An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta	University collaborators exposed to new techniques Project produced PhD and Masters degrees		Scholars in senior university positions or continuing to study
Conservation, evaluation and utilisation of plant genetic resources from the Central Asian republics and Caucasus	Improved linkages between countries and international agencies	Increased availability of germplasm in Australia	Ongoing use
Bioherbicide development for cereals in integrated weed management	Skills development amongst Vietnamese researchers		Research is continuing in Vietnam. Several collaborators have been promoted within the Vietnamese research community.
More efficient breeding of drought-resistant peanuts in India and Australia		Installation of a national research facility	Continues to be used
The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea	Survey and biological research training	Bioeconomic model	Capacity used as part of the management plan
In-store drying of grain in China	Technology transfer	Computer-assisted learning systems	Learning system continues to be widely used
Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia	Training of Vietnamese scientists Organisational capacity	Specialised laboratory in Ho Chi Minh City	Facilities remain in operation

Uptake of the R&D outputs—progress along adoption pathways

Even where the intended output is 'knowledge' of some form, the ultimate objective of ACIAR-funded research is to change something in the world—to provide producers, processors or decision-makers with knowledge and techniques that will ultimately allow them to produce better outcomes. The ultimate outcomes that ACIAR looks for include improved agricultural productivity, more sustainable resource use, higher incomes and, consequently, poverty alleviation.

In line with the diversity of projects funded, there are various pathways by which adoption of the outputs of the projects can occur. Table 3 summarises the broad adoption results.

Summarising the often complex adoption outcomes for a range of projects is inevitably a difficult task and involves an element of judgment. In the underlying adoption studies, a six-level classification was used. However, for the purposes of the summary presented here, this has been reduced to the same four-level classification used in a previous adoption report (Gordon and Davis 2007).

In this classification scheme, the lowest level of adoption is *O*, signifying no uptake of the results by either initial or final users of the outputs of the project. As Table 3 indicates, two projects had no adoption for their major output—the food-choice project in Fiji (in which a major output has not been used), and the bioherbicide project. Note that in both of these projects there was some adoption of secondary output of the projects. In a sense, the bioherbicide adoption results were a special case in that for this project the underlying research produced a negative result, so there was nothing for final users to adopt. The knowledge gained, however, becomes part of the base for future researchers.

The next level of adoption is *N*, the situation where there has been some uptake by initial users but no uptake by final or ultimate users of the research. Two projects fell into this category—leucaena management in Indonesia and use of plant genetic resources from the Central Asian republics.

The next level of adoption is *Nf*, a situation where there has been uptake by initial users, and some uptake by ultimate users. Two projects fell broadly into this category—the wool-scouring-effluent project and the monitoring mycotoxins project.

The highest level of adoption, *NF* (use by initial and final users), was achieved by the remaining five projects reported here (for at least part of their research output).

Table 3. Project outputs and the current progress of adoption

Project	New technology/ practical approach	Scientific knowledge	Knowledge, models for policy
An investigation of the determinants of food choice in Fiji and their role in demand trends for high nutritional valued foods and nutrition security	N — researchers in National Food and Nutrition Centre learned new techniques	N — underlying policy results	O — Food choice model
The treatment of wool scouring effluents in Australia, China and India	Nf — scouring technology in India N — scouring technology in China N — effluent treatment in India in one mill O — effluent treatment in China		
Development of specification and processing prediction techniques for the Chinese and Indian wool industries	NF — China, particularly major spinning mills N — India		
Leucaena management in West Timor and Cape York	N — dissemination was not an objective of the project; limited adoption to date		
An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta	NF — shrimp within the region Nf — rice variety	N — used at university	
Conservation, evaluation and utilisation of plant genetic resources from the Central Asian republics and Caucasus	N — plant breeders	N — Australian Genetic Resources centres	
Bioherbicide development for cereals in integrated weed management	O — approach not effective in actual use	N — base on which researchers can build	
More efficient breeding of drought-resistant peanuts in India and Australia	Nf — plant breeders NF — some varieties released	N — researchers	

Table 3. (continued)

Project	New technology/ practical approach	Scientific knowledge	Knowledge, models for policy
The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea			*NF* — Fishery Management Plan made law and forms the basis of actions and monitoring of various stakeholders
In-store drying of grain in China	*NF* — rice *NF* — maize, but slower *O* — wheat		
Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia	*Nf* — some uptake		

Note:

Level of uptake is summarised as high, medium, low or none using the following abbreviations:

NF demonstrated and considerable use of results by the initial and final users

Nf demonstrated and considerable use of results by the initial users but only minimal uptake by the final users

N some use of results by the initial users but no uptake by the final users

O no uptake by either initial or final users.

Factors contributing to adoption of project outputs

As identified in previous adoption reports, a number of factors contribute to the uptake and ultimate impact of projects. Broadly, these centre on whether or not:

- final or ultimate users know about the project output
- next or final users have incentive to adopt the outputs
- adoption is either compulsory or indirectly prohibited
- potential users face capital constraints, limiting ability to raise funds to adopt the outputs
- the outputs are complex to absorb relative to the capacity of the users
- use of the outputs faces cultural constraints
- adoption of the outputs increases risk and uncertainty
- there is continuity of staff in organisations associated with adoption.

Table 4 summarises the major factors contributing to adoption for the projects reported here. In most cases, results were disseminated to users through mechanisms established within the project itself. There were either explicit extension activities, or the project participants themselves were responsible for adopting the findings. In some cases, extension activities have not yet taken place, so further adoption depends upon this happening.

Economic incentives provided the major impetus for adoption once results were known. In some instances these economic incentives appeared to be very strong (as in the rice–shrimp farming project, for example). There were not many cases where adoption was either compulsory or prohibited, although in the case of effluent from wool scouring, further environmental regulation is likely to increase adoption.

Capital constraints are not strongly evident in projects reported here, although in some cases a switch to the new technology will not take place until existing capital has depreciated. In the wool-scouring-effluent project in China, for example, the existing design of mills precluded the adoption of better processing methods. As existing capital depreciates, new designs that allow better processing will presumably be adopted. While this is partly a capital constraint, it also reflects a judgment about the timing of relative benefits and costs of adopting new designs.

Outputs seem to have been pitched at an appropriate level of complexity for the projects reported here. In the rice–shrimp farming project, farmers were clearly able to understand the implications of the findings and, in China and India (in the wool processing projects), a strong technical capability within the partner organisations meant that the otherwise complex processing implications were well understood, contributing to adoption.

Cultural constraints did not emerge as an issue in these projects, and risk did not seem to be an issue in adoption. Continuity of staff was, however, an issue in the Fiji food-choice project.

Lessons

The results that emerge from the adoption studies reported here provide a number of lessons for the establishment and conduct of ACIAR-funded projects.

Choice of partner

A number of the adoption studies reported here noted the importance of the choice of research partners to the success of the project.

- The collaborating agency needs to be actively involved in the relevant industry sectors, particularly if the project involves a processing chain in between the producer and the final consumer. This is strongly evident, for example, in the wool-processing projects.
- In policy-related projects, the research partner needs to have a direct conduit to the policymaking process, otherwise impacts are considerably less likely. For example, the Fiji food-choice project expressed some concerns about the partner's ability to influence policy choices.

Table 4. Factors influencing adoption and impact—analysis of the reviews

Factors contributing to uptake	Factors inhibiting uptake
Do potential users know about the outputs?	
▪ For the Chinese and Indian wool (scouring and spinning) projects, the partner organisations were either the final users, or were closely associated with those users. Circumstances in the plant genetic resource project were similar. ▪ The rice–shrimp farming project in the Mekong Delta produced extension material that was disseminated to farmers in the region. In addition, leading farmers were used for testing and demonstrating experimental techniques. ▪ In the case of drought resistance in peanuts, new varieties are being evaluated using farmer participatory approaches.	▪ Rapid changes in political circumstances, such as in the Fiji nutrition project, may mean that awareness of the project has declined over time. ▪ Dissemination of results to users was not a major component of the leucaena management project. Without this, there is unlikely to be further adoption by final researchers.
Are there sufficient incentives to adopt the benefits?	
▪ A clear financial incentive for adopting project findings is evident behind high levels of adoption in the wool projects, the rice–shrimp farming project and the grain postharvest project. ▪ In the barramundi fishery project, major stakeholders appeared to be actively engaged in the project and interested in the outcome, significantly contributing to the success of the outcome.	▪ Potential adopters may consider that there are more profitable alternatives to the technology adopted in the project. This is evident, for example, in the case of Chinese mills in the wool-scouring-effluent project. In the rice–shrimp project in the Mekong Delta, integrated rice–shrimp practices have been dropped in favour of intensive shrimp production.
Is adoption compulsory or effectively prohibited?	
▪ Tighter environmental standards are likely to increase uptake of wool-effluent technologies.	
Are there capital constraints on the ability of potential users to raise funds?	
	▪ In China, design of scours in existing mills precluded, for cost reasons, the adoption of better processing methods.
Are outputs complex in comparison with the capability of the users?	
▪ For most of the projects presented here, there appeared to be sufficient capacity for the users to adopt results.	▪ Some studies considered that partner organisations had insufficient funding to allow them to complete the work needed in the project.

Table 4. (continued)

Factors contributing to uptake	Factors inhibiting uptake
Are there cultural barriers to adoption?	
▪ No examples	
Does adoption increase risk or uncertainty?	
▪ Not evident in the projects reported here	
Was there sufficient continuity of staff to ensure adoption?	
	▪ The food-choice project in Fiji suffered from a lack of continuity, in part due to unrest in the country.

Extension activities within the project

A couple of the adoption studies noted that more time could profitably be devoted to extension activities and that the inclusion of specific extension activities within a project can significantly enhance the prospects of adoption. In addition, the collaborating agency needs to have the incentive and ability to continue with extension activities after the project finishes. This is evident, for example, in the leucaena project.

In projects with no formal inclusion of extension activities, ACIAR needs to be confident—before the project starts—that either the commercial incentives for adoption, or the extension infrastructure within the partner country, are sufficient to ensure some adoption in the future. This is particularly important in poor and marginalised regions where knowledge transfer may otherwise be very slow.

Multidisciplinary research program

Some adoption studies noted the extent to which the integration of scientific, social and economic analysis improved the overall quality of the research. The different disciplines were able to provide information essential to enhancing the products of other disciplines. While this makes overall project management considerably more complex, the benefits were considered worthwhile. This is strongly evident, for example, in the rice–shrimp farming project in Vietnam and can be seen in all projects that involve engaging farmers in novel practices that have new economic implications.

Collaboration within the project

Collaboration between researchers, extension workers, local policymakers and farmers was considered to be extremely valuable. This not only enhances the information from the point of view of researchers, but also contributes significantly to the subsequent adoption of outputs, which is closely related to the point made earlier about multidisciplinary research. The more interaction between different points in the research–production chain that the project allows, the more scope there is for transfer of information in both directions.

For technology-transfer projects, good relations with the technical community (that is, the community of researchers, engineers and others charged with solving day-to-day technical problems, particularly in processing industries) contribute enormously to the outcome. This may be the result of personal factors, but is also largely influenced by the perception that the project has something significant to offer. The Australian partner institution's reputation and track record is likely to contribute significantly to this.

The value of 'dry holes'

The bioherbicide project raises the interesting question of how to treat negative findings from an adoption (and impact evaluation) perspective. On the one hand, nothing has been adopted by farmers, as the research found that the proposed approach is unlikely to work. On the other hand, this provides a base to ensure that similar dry holes are not explored in the future. What becomes crucial is that the scientific reasons for the lack of success are communicated to other researchers.

Regulatory incentive

Changing environmental regulations are likely to affect adoption of particular technologies significantly (as, for example, in the wool-scouring-effluent project). Regulation, of course, affects the choice of technologies in many ways. But while regulation may drive a particular technology, there is no guarantee that this will have net benefits for the community unless the regulation was well targeted in the first place. Some care needs to be taken when relying on regulation as a major driver of adoption.

Commercial incentive

The results from these studies further illustrate the now well-known result that commercial or financial incentive remains the major driver of adoption. While the underlying research may be 'public good', the existence of good financial reasons to adopt the outcomes of the research is almost a guarantee of adoption (unless there are serious policy distortions in the partner country). Most of the five cases with the highest level of adoption had strong immediate commercial consequences for the ultimate users.

An investigation of determinants of food choice in Fiji and their role in demand trends for high nutritional valued foods and nutrition security (ADP/1998/095)

Philip Hone

Project number	ADP/1998/095
Project name	An investigation of determinants of food choice in Fiji and their role in demand trends for nutritional valued foods and nutrition security
Collaborating institutions	Australia: University of Sydney; Deakin University Fiji: National Food and Nutrition Centre; Ministry of Agriculture, Sugar and Land Resettlement; School of Nutrition, Fiji School of Medicine
Project leaders	Kate Owen (University of Sydney), Philip Hone (Deakin University) and Seini Seniloli (Fiji School of Medicine)
Duration of project	1 January 2000 – 30 June 2004
Funding	$455,589
Countries involved	Fiji
Commodities involved	Food demand in general
Related projects	ANRE1/1996/134, CS1/1996/179, CS2/1993/006, PHT/1997/025

Motivation for the project

This project originated from concern about food choice and health issues from staff in the National Food and Nutrition Centre (NFNC) in Fiji. The project was developed at a time when there was growing awareness of, and concern about, nutritional issues in the South Pacific. These nutritional issues focused on the impact of diet on health and non-communicable diseases. Staff from the NFNC approached an ACIAR program manager about the possibility of ACIAR funding work on this issue. The original project had two basic components: a study of food-choice decisions at the household level and the development of a PC-based food-choice model to train people in making appropriate food choices. The study of food choices was based around a national household survey using a 'choice modelling' survey instrument. The food-choice model was planned as an optimising linear program (LP) similar to that used in agriculture to determine least-cost food rations.

What has the research project produced?

The project produced the following outputs:

(i) The Fiji Food Choice Model. A preliminary version of the model was launched at the project's final workshop. A user manual was prepared, printed and distributed. The manual included a CD of the model. A laboratory session was held for staff from the NFNC and University of the South Pacific (USP).

Food fit for a king! Maintaining a balance between protein, carbohydrates and vegetables contributes to healthy living.

Labasa Municipal Market, July 2005. Local municipal markets in Fiji provide a wide range of lower priced and nutritious fruit, vegetables and other foods.

(ii) Project workshop and nutrition research papers. The workshop was attended by people from across the Fiji policy community. A range of policy papers were presented by project staff and others in related areas. Other papers included:

- Owen K. 1999. What do we know of consumer preferences in the island countries of the South Pacific? Presented at 43rd Annual Agricultural and Resource Economics Society Conference, Christchurch.
- Owen K., Vatucawaqa P. and Chand J. 2002. Understanding food choices in Fiji. Presented at 46th Annual Agricultural and Resource Economics Society Conference, Canberra.
- Hone P. 2004. Food choice and nutrition in Fiji. Presented at 49th Annual Agricultural and Resource Economics Society Conference Melbourne.
- Hone, P. 2004. Food choice and nutrition in Fiji. ICFAI Journal of Agricultural Economics 1(2), 13–30.

In addition, the capacity developed by the project included:

(i) staff in the NFNC and the Fiji School of Medicine (FSM) undertaking a range of formal and informal training exercises throughout the project

(ii) the Fiji-based staff gaining experience in looking at different approaches to running a major survey and analysing survey information.

Adoption—how the project outputs are being used

The survey training provided by the project was reported to have been of considerable value to the NFNC. The centre reported that the experience with the ACIAR project influenced what questions they included in their national survey. Moreover, they reported that the analysis and interpretation of the results leading to the preparation of the final report on the national survey was substantially influenced by their experience in this project. Staff from FSM made similar comments on the value of their exposure to the project, again mentioning enhanced data-analysis skills.

The Fiji Food Choice Model has not been used. It would appear that there has been no attempt to use the model since the workshop in June 2004. The model requires further development before it can be used.

While there is no evidence that any of the policy ideas coming from the analysis of the data have been taken up in government policy, it seems safe to conclude that the policy results from this project became intermediate outputs of some use to the next user. The policy papers were communicated to a targeted policy audience in Fiji and, as such, became part of the information base upon which current and future decisions are and will be made.

Staff turnover and other disruptions to the project made it difficult for the activity to stay on focus and achieve local ownership. These disruptions included a coup midway through the project. In addition, staff in Fiji indicated they were inadequately funded (or not funded at all) for what they had to do in the project. Also, the high turnover of incumbents in the position of Director of the NFNC was a major issue.

FSM and USP staff expressed interest in using the food-choice model in the future if it was further developed.

Impact—the difference the project has made or is expected to make

The lack of adoption of the model and limited direct use of the data collected in the survey means that any impact from this project is probably modest. There has been an impact through the enhancement of the professional skills of staff directly related in the project. Staff from NFNC and FSM expressed the opinion that this project had a significant and substantial impact on their professional capacities in terms of data analysis, report writing, and survey planning and management. While policy-relevant information did flow to the policy community in Fiji, there was no evidence of any consequent changes in decisions concerning local nutrition policy.

The treatment of wool scouring effluents in Australia, China and India (AS1/1997/069)

Jock Christoe

Project number	AS1/1997/069
Project name	The treatment of wool scouring effluents in Australia, China and India
Collaborating institutions	Australia: CSIRO Textile and Fibre Technology (TFT) China: Ministry of Water Resources, Water Environment Monitoring Assessment and Research Center (WEMARC), Beijing India: Ahmedabad Textile Industry's Research Association (ATIRA), Ahmedabad
Project leaders	Jock Christoe (TFT), Zhou Haidong (WEMARC) and S.R. Bhatt (ATIRA)
Duration of project	1 July 1999 – 31 December 2003
Funding	$1,052,634
Countries involved	Australia, China and India
Commodities involved	Wool
Related projects	AS1/1997/070

Motivation for the project and what it aimed to achieve

In response to the demands of a more affluent society and the problem of increasing environmental degradation, the Chinese and Indian governments have been taking a tougher stand against environmental pollution in recent years. Most of the wool-processing industry is under threat of closure if it cannot demonstrate that it is not polluting the environment. The loss of this market would have dire consequences for not only Australia's woolgrowers but also for Australians in general through the lost income, which is estimated at about $800 million per year.

Wool is regarded as both a high-quality and environmentally friendly fibre. These two factors are extremely important in maintaining its position in the global fibre market. Greasy wool contains substantial amounts of natural contaminants, such as wool wax, dirt and suint (water-soluble material), as well as pesticide residues from the treatment of the sheep to prevent disease. These contaminants are removed during the wool-scouring process and are discharged as an effluent that is highly polluting. Consequently, wool has been regarded as a highly polluting and dirty fibre to process. The organic effluent load from a typical Australian wool-scouring plant is approximately equivalent to the sewage from a town of 50,000 people.

The prime objectives of this project were related to reducing the environmental impacts of the wool-processing industries in China and India. This was to be achieved by first optimising existing systems, then evaluating chemical and biological treatments to reduce the levels of contamination to acceptable levels.

Workers in India opening bales of greasy wool. Working conditions are poor, with high temperatures and slippery floors.

The first major objective was to develop an understanding for the differing performances of the contaminant-recovery systems in the wool-scouring lines in the different countries. Factors that were investigated included characterisation of the contaminants on the greasy wool and determination of the performance of the processing equipment, both the wool-scouring line and its associated contaminant-recovery loops.

The second major objective was to carry out environmental audits at mills in China and India with the aim of determining compliance with local regulations and comparing performance with scours in Australia.

The third major objective was to investigate the use of effluent-treatment systems under the conditions that are peculiar to the developing countries. CSIRO Textile and Fibre Technology (formerly Wool Technology) has carried out a considerable amount of work into different methods of treating wool-scouring effluents with the aim of developing a suite of technologies that can be applied to meet a wide range of environmental discharge regulations. The CSIRO approach involved a combination of chemical flocculation and biological treatments.

A chemical-flocculation pilot plant was to be installed at mills in Australia, China and India in order to evaluate this technology under different operating conditions. This pilot plant had the capacity to treat nearly all of the effluent from a typical Chinese or Indian scouring line. The sludge produced in the process contained most of the wool wax and dirt that was in the scouring effluent. Studies were to be carried out in China and India to evaluate the effectiveness of composting as a method for converting the sludge into a resource containing no harmful chemicals.

What the research project produced

Technical outputs

Objective 1—Training of research personnel. Research personnel from WEMARC and ATIRA were trained in laboratory techniques for analysing both wool and liquid samples. A training manual was given to each participant in the training program. Further training was given on annual review visits to the laboratories, especially in terms of data analysis and evaluation of results. It was hoped that the skills acquired during the project would enable ATIRA and WEMARC to provide an analytical service to their respective textile industries.

Objective 2—Comparison of Chinese and Australian wools. Several small scouring trials were carried out using the CSIRO scouring line in Geelong. There was little difference in the removal of the solvent-extractable matter (wool wax) but there were large differences in the removal of particulate matter (dirt and non-wool proteins) from the greasy wool. In addition, the scoured Chinese wools were inferior in brightness and yellowness.

Objective 3—Comparison of Chinese and Western contaminant-recovery equipment. There did not appear to be any difference between Chinese and European primary disc centrifuges in the efficiency of wool-wax recovery.

Objective 4—Process audits. A major component of the project involved working with 14 mills (4 in India, 6 in China and 4 in Australia). They represented all segments of the industry from commission scourers, commission combers and vertical mills. The teams carried out process audits at each of the mills. In addition two series of comparative processing trails were carried out in which the same wool was scoured at each of the participating mills before being made into top at CSIRO. This was the first time that a comprehensive study of the effects of scouring practice had been carried out.

Each mill had a different approach to wool-scouring practice either in terms of the equipment or of the modes of operation. It is interesting to note that the scouring practices, contaminant recovery if any and wastewater treatment are almost predicated by the layout and design of the wool scour.

The two series of comparative processing trials demonstrated the large adverse effect that the wool-scouring process can have on subsequent processing performance. These trials have suggested that an investment in modern scouring equipment and processes would produce rapid economic benefits for a mill. The results showed that substantial losses are incurred by scouring wool through a typical Chinese scouring line. Annual losses for a 19–20 micron wool would be about US$2.4 million for a typical scouring line producing 2,000 tonnes per year and having losses of 4% more than Australia. When the losses are calculated in terms of lost fabric production, they would be US$7 million. Consequently, the payback period for investing in modern technology would be very short. A substantial bonus would be that the mill would find it easier and cheaper to reduce environmental pollution.

Objective 5—Computer model of a wool scour. CSIRO has developed a spreadsheet to model the behaviour of a wool scour in real-time rather than at equilibrium using matrix calculations. The model's predicted accumulation of contaminants mirrored actual mill results.

Objective 6—Chemical treatment of scouring effluents. Sirolan CF, the chemical treatment system developed by CSIRO, removed virtually all of the wool wax and dirt from scouring effluents with an efficiency of about 90% for chemical oxygen demand (COD) removal in pilot-plant trials at mills in the three countries.

Objective 7—Composting of chemical sludge. The amounts of sludge generated in the trials with the chemical treatment pilot plants in China and India were insufficient for composting trials.

Objective 8—Biological/chemical treatment to remove recalcitrant COD. A component of the water-soluble contaminants remaining in the concentrate from the chemically flocculated scouring liquor is not readily biodegradable. This means that the biological oxygen demand (BOD) in the biologically treated effluent might be very low but the COD remains relatively high. Laboratory studies showed that a chemical oxidation treatment rendered these recalcitrant chemicals biodegradable such that a second biological treatment reduced the COD to acceptable levels.

Capacity developed by the project

Additions to the stock of knowledge included:

- demonstration that poor scouring can lead to large processing loses in terms of both product and money. This finding came as a by-product of the project in which the aim was to audit and compare the scouring performance of the mills participating in the project.

- demonstration that the Chinese-made disc centrifuges perform as well as their European-built counterparts, providing that the machines are well maintained.
- demonstration that a spreadsheet-based program can be used to model the performance of a scouring line in real time rather than at equilibrium. This outcome was only partly realised because the activity was curtailed when the project was extended.
- demonstration that the Sirolan CF effluent treatment could perform as well in China and India as it did in trials in Australia.

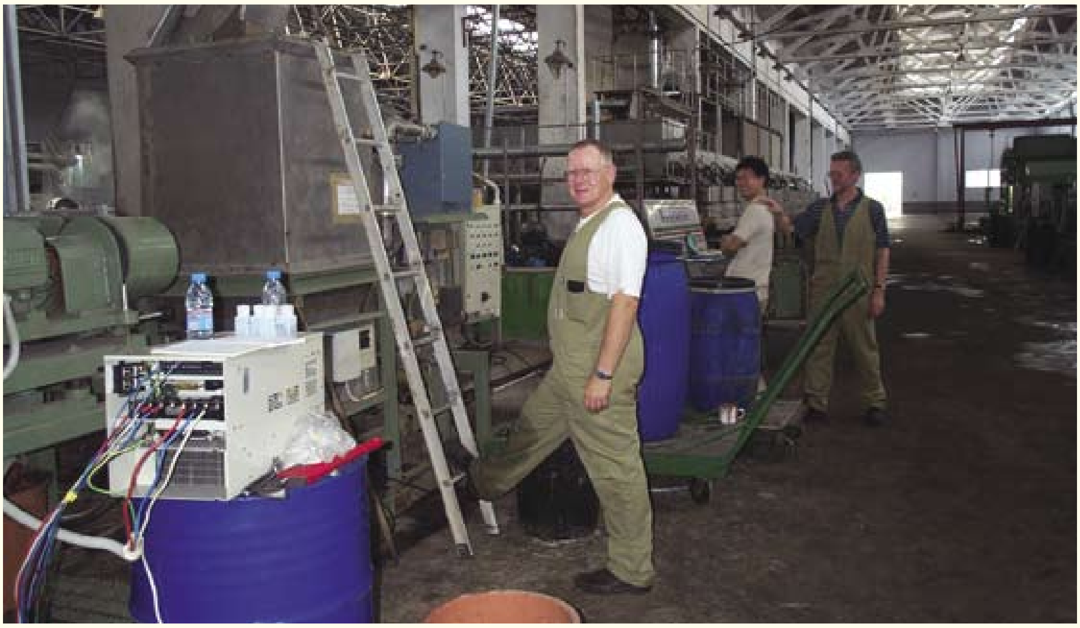
Adoption—how the project outputs are being used

The adoption of better technologies for improved processing performance and wastewater treatment varied from country to country.

The project was structured to help the wool-scouring industries in Australia, China and India to optimise their scouring and contaminant recoveries before effluent treatment options were considered. Consequently, scouring performance and effluent treatment are considered separately.

Scouring performance

In Australia, the technologies for improved processing performance in terms of water use, chemical use and productivity were already in place as a result of close contact between CSIRO and wool mills over many years.



A pilot plant for the Sirolan CF system for treating wool-scour effluents, installed at a Chinese mill.

In India, several of the mills were very keen to adopt methods for improving their processing performance. The changes recommended in the operation at these mills were adopted over the duration of the project. For example, during a seminar for the Indian textile industry, a director of one of the mills participating in the project made unsolicited public comments about the project. This is a transcript of what he said:

> The ACIAR project for scouring/environment has benefited the wool processing industry in India immensely. The project headed by Dr Jock Christoe has given us a new direction to improve the scouring and environment at our factory. We were fortunate to have consultations with Dr Christoe from time to time and today we are truly a nil discharge company where all the solid sludge and treated effluent is used in house beneficially. The project has also given our organisation a direction where the concerned people are as excited for improving environment as they are for producing quality wool tops. We wish that these mutual interactions are continued to further improve the processes. We must say that the project initiated by Australian Government has done full justice.

In China, there was a low level of adoption of the ideas to improve processing performance, principally at the more modern wool-scour mills. With the remaining mills, the design of the scours precluded the adoption of better processing methods.

Effluent treatment

In Australia, the adoption of improved wastewater treatment systems, such as Sirolan CF, occurred during the life of the project. Two of the mills adopted the technology and one made provision for its adoption. The principal driver for its adoption in Australia was the large reduction in the costs of disposal of the scouring wastewater to the sewer.

In India, personnel from one of the mills visited some mills in Europe using the Sirolan CF technology and, by adaptation, developed their own version. The Sirolan CF pilot plant was run successfully at a second mill. The mill was sufficiently interested to try burning the sludge and to make a video of the pilot-plant trials.

A worker preparing 'cannon balls' from the Sirolan CF sludge for incineration trials at an Indian mill.

The remaining mills in India showed interest initially but were relatively uninterested in changing their operations, possibly because of their small output.

In China, there was no adoption of the effluent-treatment outcomes. In the reports prepared for the mills following the first series of comparative processing trials, specific recommendations were made about the effluent treatment objectives. Despite these recommendations, there was no adoption at any of the mills. One mill stated that it believed the polymer used with the technology was too expensive compared with the locally available polymers. Other mills were reluctant to change their practices despite cost evidence to the contrary. Nearly 4 years after the completion of the project, one mill is now contemplating change.

Adoption in the future

Adoption of the outputs in China and India will depend on factors such as:

- government pressure to reduce environmental pollution
- market pressures to produce products having a low environmental profile (an example of this approach is the European Union 'Ecolabel')
- emergence of an effective organisation representing wool processors
- a willingness from the wool processors to change their existing practices and equipment (the economic impact results could have a large influence on the industry)
- more extensive extension programs to bring the outputs to the notice of a wider audience
- the emergence of a 'product champion' in both India and China
- community pressure for mills to change. Many mills operate an anaerobic biological treatment at some point of the effluent-treatment process (usually towards the start). The malodours generated by this sort of treatment could have adverse affects on local communities. One mill has covered the anaerobic treatment process with a roof to overcome this problem but it is only a short-term solution.
- sufficient protection of intellectual property. The licensee for the effluent-treatment technology (ANDAR) needs to be confident that the technology would not be copied, as has happened in India.

Impact—the difference the project has made or is expected to make

Characterising the impact

The value of the research is that it has the potential to change the way wool scours are operated in India and China. Currently many mills are not operating optimally and consequently they are not making the most of the scouring operation.

The mills generally have very poor or no dirt-recovery systems other than settling pits for the effluent once it has been discharged from the scour. This means that dirt accumulates around the scouring line and in discharge channels in addition to being collected in the pits. An advantage in centralising and optimising dirt recovery is that it would make the wool scour a better and safer place to work.

The working environment in the wax-recovery plants was highly dangerous because the wool wax spread over the floors makes them very slippery. This may be coincidence but when one mill moved its wool-wax recovery plant next to the wool-scouring line (at our suggestion) the area was no longer as dangerous. In a typical Australian mill the wool-wax recovery plant is located next to the wool scour and is operated by the scour operators. The working environment is cleaner and safer. One outcome from this project could be an improved working environment for wool-wax recovery operators. An additional advantage is that the mill could recover more wool wax and achieve a better economic outcome. Currently the value of recovered wool wax is US$2 per kilogram.

The approach of the mills to wastewater treatment has been to keep adding different systems to their existing wastewater treatment plants in order to meet the increasingly tougher environmental discharge limits. We believe a better approach would be (1) to reduce the volume of the wastewater streams, (2) to recover as much of the contaminants as possible and (3) to separate the different effluent-discharge streams and to treat each using the most appropriate technology. This means integrating wool scouring, contaminant recovery and disposal, and wastewater treatment. In this way we believe it would be possible to improve the working environment as well as reduce the environmental impact from wool scouring. This applies to both solid and aqueous wastes.

The participating mills have benefited from being able to compare their performance with 13 other mills over the two comparative processing trials. During the mill visits, suggestions on improving performance were made to the mills and these have been adopted in many cases. Also among the potential benefits to the processing industries in China and India was that they would have access to cheaper and better technologies for treating their effluents to meet environmental discharge limits.

Wool scouring requires quite large amounts of good-quality water. This means that wool-scouring lines have generally been located near natural watercourses, thereby competing with the local population for the use of the water. Therefore, large social benefits will flow from improving the quality of the watercourses, both through reducing the volume of treated effluent being discharged and through eliminating the pollution in the discharges.

Workers in the mills would benefit from working in the safer environment that would result if the mills adopted better work practices. They would have a better and safer working environment.

Communities outside of the wool-processing plants would have a better living environment, and farming communities would benefit from access to the composted sludge and the potassium-rich, water-soluble residues. As many families, the women in particular, take their drinking and cooking water from the same watercourses into which the scouring effluents are discharged, they would benefit from the improvement in water quality.

Factors affecting the magnitude of the impact

The magnitude of the impact of the project on the wool-processing industry will be increased if:

- the Chinese Government forces mills to adopt better effluent-treatment systems in order to prevent pollution of the environment, and surface waters in particular
- the institutions representing the Chinese wool-processing industry, such as the Chinese Wool Textile Association, become more active in representing the processors in discussions with government departments.

Development of specification and processing prediction techniques for the Chinese and Indian wool industries (AS1/1997/070)

Bill Humphries and Shouren Yang

Project number	AS1/1997/070
Project name	Development of specification and processing prediction techniques for the Chinese and Indian wool industries
Collaborating institutions	Australia: Woolmark Company, Cooperative Research Centre (CRC) for Premium Quality Wool, CSIRO Textile and Fibre Technology China: Dong Hua University (DHU), Xi'an Polytechnic University (XPU) India: Indian Woollen Mills Federation
Project leaders	Dr Bill Humphries (CSIRO Textile and Fibre Technology), Professor Ding Xin (China Textile University), Professor Baoyu Zhu (XPU), and Dr A.C. Chaudhuri (Indian Woollen Mills Federation)
Duration of project	1 July 1999 – 30 June 2002; extension 1 July 2002 – 30 June 2003
Funding	$956,630
Countries involved	Australia, China and India
Commodities involved	Wool
Related projects	AS1/1997/69

Motivation for the project and what it aimed to achieve

The major aim of this project was to carry out research to develop, in a form suitable for Chinese and Indian spinning mills, techniques that can be used to predict yarn quality and spinning performance from knowledge of fibre properties.

What the research project produced

The most pleasing aspect of the project was the level of cooperation received from the mill and university partners. This cooperation was central to the success of the project. Mills carried out very large processing trials and supplied large amounts of processing data. All the mills carried out the project work at their own expense, demonstrating their commitment to the project.

Based on comprehensive data compiled during the project and from additional mathematical modelling, the spinning prediction model, Yarnspec, has been improved to suit the needs of Chinese mills. In addition, mill-specific Yarnspec prediction models have been developed for individual mills. The new Yarnspec model can predict not only the world's best practice but also the mill's specific performance. This makes Yarnspec more useful as a quality-control tool for spinning mills since it will allow a mill to easily optimise the input parameters of fibre properties and machine settings for its specific circumstances.

Visit to Ruyi Group for ACIAR adoption study, May 2007. L–R: Ms Ding Cai Ling, General Manager of Ruyi Worsted Spinning Company; Dr Shouren Yang, CSIRO Australia; Mr Qiu Dong, Managing Director of Ruyi Group.

The modern spinning machinery installed in the mill of one of the project partners.

A neural-network prediction model was also developed during the course of the project. This will be useful in the future for developing mill-specific versions of Yarnspec and for easily keeping the mill-specific model up to date as the performance of the mill improves.

Through the direct participation of the six leading Chinese worsted-spinning mills and the two major Chinese textile universities, Yarnspec spinning-prediction technology has been introduced into the Chinese wool industry. Yarnspec is now a well-known name in the Chinese wool industry and at the two Chinese textile universities.

The benchmarking of Chinese mills provided vital information on the mills' performance relative to the world's best practice, which in turn provided an important stimulus for improvements in performance. Through years of effort, the partner mills have made excellent progresses in catching up with, or even eclipsing, the existing world's best practice. Some partner mills are now leading the Chinese wool industry in product quality and fashion trend. Wool fabrics produced by the partner mills have become the choice of some of the world's leading garment manufacturers for production of top-brand garments.

Objective measurement of fibre diameter was implemented for Chinese domestic wool in a central laboratory in the Lanzhou Sanmao mill and appropriate sampling methods instituted so that the mill was able to use the objective measurement of fibre diameter during wool sorting and consignment building. The implementation of fibre-diameter measurement for domestic wool in the mill is a major achievement of the project.

The project has enhanced the linkage between university teaching and research activities and industry practice. Processing prediction technology and quality control have been introduced into universities as important areas for teaching, research and consultation. As a direct result of the project, partner universities and mills have received significant additional funding from the Chinese Government for implementation of the technologies introduced by the project.

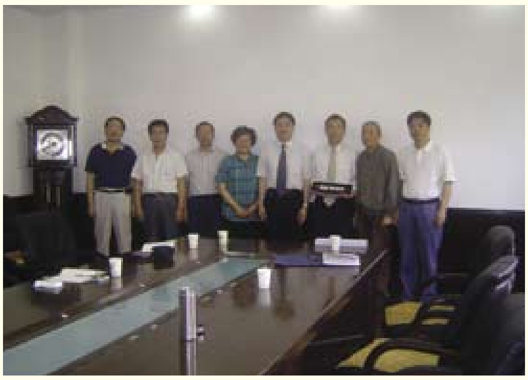
The domestic wool subproject has clearly demonstrated the need for good clip preparation and the benefits of using objective measurement in consignment-building decisions. Importantly, this has been commercially demonstrated at the mill level (112 tonnes of wool were processed in the trial described above) and, because of the commercial advantage gained, the mill has sent strong signals to the production industry aimed at improving clip preparation and the general quality of the wool delivered to the mill. The project has therefore started what is hoped will be a commercially driven, sustainable process that will result in an improvement in the quality of wool delivered to the mill, a reduction in mill costs and improved returns to wool producers. The outputs clearly demonstrate that the research undertaken within this project has the potential to significantly contribute to the reform of the domestic wool-marketing system.

Nanjing Wool Market (NWM) has put considerable effort into improving on-farm practices, shearing, clip preparation and packaging. From 1998 it has been developing the domestic wool-marketing system in collaboration with local wool farmers' associations in Xinjiang and Inner Mongolia. Excellent progress was made from 1998 to 2004 in reforming the domestic wool-marketing system. However, there has been a slowdown in the reform in recent years due mainly to the lack of support from the state and local governments.

In India the benefits of the project were summarised by the project review committee as follows:

> We were impressed with the experimental design of the project, and although not all phases of work have been completed at the time of our review, there are positive results available. Most of the participating mills are already finding benefits from the introduction of Yarnspec into their mill quality control. It has benchmarked their current yarn quality and spinning performance to world best practice, and enabled them to begin analysing how to improve quality and profitability.

In the major wool-input optimisation trial carried out in India, two batches of 4 tonnes of greasy wool were assembled from 5–6 sale lots purchased at auction in Fremantle. The first batch conformed to the typical specifications of leading Indian mills. The second batch greatly increased the allowed range of staple length and strength. The batches were spun into yarn at five Indian mills. The mean yarn properties and spinning performances were found to be essentially identical, within errors, except for the strength properties of the yarns, where the conventional batch was marginally superior. Analysis of auction data showed the batch made up with the wider range of staple properties would be cheaper, and more wool would be available for the mills' buyers to bid on at auction.



Visit to Xi'an Polytechnic University for ACIAR adoption study May 2007. Left (L–R): Dr Ren Xueqin, Mr Zhang Dekun, Mr Zhao Wei, Prof. Zhu Baoyu, ex. Vice-President of XPU, Prof. Huang Xiang, Vice-President of XPU, Dr Shouren Yang, CSIRO Australia, Prof. Yao Mu, Honorary President of XPU, and Prof. Sun, Director of S&R Department. Right: Prof. Zhu Baoyu and Dr Yang.

Adoption— how the project outputs are being used

At the start of the project the quality-control system at the Chinese partner mills was poor from the international standards point of view. Their main focus was to keep the raw-material costs as low as possible at the expense of product quality and ignoring the overall economic efficiency. This improper mill-management policy, had, to some extent, contributed to the breakdown of many state-run mills in China in the 1990s.

Through adoption of the processing-prediction and objective fibre-measurement techniques the partner mills have gained a better understanding about the importance of choosing the most suitable wool tops to ensure product quality and overall economic efficiency. The partner mills are moving away from trying to reduce material costs at the expense of quality and overall economic efficiency. This has led to significant savings through optimum wool-fibre selection and improved product quality and processing efficiency.

Before the project, the quality control system at the partner mills was based mainly on experience. They used their experience to purchase wool top and there were no adequate specifications for the wool tops they wanted. As a result, the mills suffered significant economic losses from using poor wool tops, which resulted in poor yarn quality and spinning performance. This led in turn to low overall economic efficiency.

Now the mills have adopted the international standard specifications for wool tops and they consider the overall quality of wool tops more wisely by taking into account the influences of various fibre properties, including fibre diameter and length, and their variations. The mills now have a good understanding of the importance of fibre length and the trade-off between fibre diameter and length. By applying this trade-off, mills are able to optimise wool-top selection by choosing the most suitable wool tops to meet customers' requirements for the end products while keeping the material costs low. The fibre lengths of wool top used by the partner mills have increased significantly, by about 10–15 mm, which has been important in contributing to the improved yarn quality and spinning performance.

Fibre damage in top dyeing is a key factor affecting yarn quality and spinning performance. Before the project, top dyeing quality at the partner mills was poor, which resulted in significant damage to the fibre strength, which led in turn to poor yarn quality and high spinning ends-down. By adopting spinning-prediction and low-temperature dyeing techniques partner mills have optimised top-dyeing procedures. As a result, fibre damage in top dyeing has been greatly reduced, leading to significant improvements in yarn quality and processing efficiency. Data collected from Ruyi show that from 2002 to 2006 fibre damage in top dyeing at the mill has been reduced by 58%, 54% and 66% for fine, superfine and ultrafine wools, respectively. This indicates the same percentage increase in the resulting yarn strength. As a result, spinning ends-down has been reduced by 35% and weaving efficiency improved by 13%. This has led to a reduction in labour for weaving operations by 100%. Similar progress has been made at other partner mills.

The quality-control system at these mills has changed from 'fire fighting' to 'fire prevention'. This helps mills minimise economic losses caused by producing bad lots due to poor material selection or wrong specification of spinning parameters.

The benchmarking study in 2001 indicated that all the mills' performances were below the world's best practice. For some mills the spinning ends-down rate was as high as 5–10 fold that of the world's best practice. Over the years, all the partner mills' performances have significantly improved and are catching up with, or even outperforming, the world's best practice. Pleasingly, the best of the partner mills have now become the leaders of the Chinese wool industry for fabric quality and fashion trends and the dominant suppliers of high-quality wool fabrics to the key overseas markets for the Chinese wool-textile industry.

As claimed by the mill and university partners, the most important change is the change in people's thinking and the concept of quality control. Under the influence of the project, many Chinese wool-spinning mills have adopted the new concept of scientific management for the traditional wool industry.

Due to the higher level of competence in the Indian mills, the improvement in the performance of the partner mills is less profound. However, the Indian mills have taken advantage of the economics of better fibre specification for spinning. The project also highlighted the damage due to dyeing occurring in the mills and, although no specific follow-up has taken place, it is likely that the mills would have improved their performance in this area.

Impact—the difference the project has made or is expected to make

Characterisation of the impacts

At the 2001 Shanghai Conference of the International Wool Textile Organization (IWTO), Shandong Ruyi claimed, on behalf of the Chinese wool industry, that by adopting the new technology, the quality-control system at Chinese mills has changed from 'Experience Based System' to 'Scientific Pre-Known and Pre-Control System' (sic), which has resulted in a significant improvement in yarn quality.

A partner mill has claimed recently that:

> Yarnspec has played a critical role in improving top dyeing and spinning quality. Yarnspec has produced a profound impact on the Chinese wool industry and the impact is beyond the technology itself. The wool industry is a traditional experience-based industry. Yarnspec has introduced a new concept of prediction and pre-control into the industry. This will produce great impact on the Chinese wool industry through revolutionising people's thinking.

The partner mills have upgraded their testing laboratories by purchasing advanced test equipment and establishing conditioned testing rooms. This will be vital to their efforts to improve their yarn quality in the future. Some partner mills have established technology or R&D centres that have played an important role in facilitating applications of new technology and new product development.

The impact of the project has extended beyond the six partner mills. This is evidenced by a statement by Lanzhou Sanmao at the 2004 IWTO Shanghai Conference:

> Lanzhou Sanmao and most Chinese worsted spinning mills have established internal quality control and quality assurance systems. Some enterprises have gained the ISO9000 authentication. These companies have abandoned the old experience-based quality control concept and adopted

> a new system, which is based on scientific objective measurement and processing prediction. The companies are now paying high attention to raising the corresponding quality target for intermediate products according to the quality requirement for the final products. We are confident to say that the Chinese wool industry is definitely moving from the traditional experience-based management towards the scientific know-how new system.

The success of the ACIAR project has created strong demand from the Chinese wool industry for a wide adoption of the spinning-prediction technology and quality-control procedures to improve yarn quality and spinning efficiency in China. This is evidenced by overwhelmingly strong support from the Chinese wool industry for a proposed project 'Enhancing China's capacity for processing superfine Australian wool' for the Australia–China Agricultural Technical Cooperation Programme. The Chinese Wool Textile Association, NWM, 11 major wool-top making and spinning companies and three leading textile universities have expressed strong interest in and support for the proposed project.

In 2001 the Chinese Government listed the development of a spinning-prediction system as one of the six key wool-related projects in a major program supported by the state government, and granted significant funding for the implementation of the program.

In June 2006 the Chinese Government announced 'The Eleventh Five Year Plan' for the textile industry. Optimising processing and improving product quality, which has been the key objective of the ACIAR project, has been adopted as a guiding policy for the Chinese wool industry. Professor Zhu of XPU stated that this is the best evidence of the impact that the project has made on the Chinese wool industry.

At the start of the project, Australian wool exported to China was about 25% of the total exported wool. In 2002 it increased to 40% and in 2006 reached 64%. The successful transfer of spinning-prediction technology into the Chinese wool industry has no doubt played a part in promoting the value of high-quality Australian wool in China.

The domestic wool subproject conducted successful pioneering work into the introduction of objective measurement into the Chinese domestically grown wool supply chain in collaboration with Lanzhou Sanmao and NWM. With strong influence from the project, excellent progress was made in advancing the reform of the domestic wool-marketing system during the project period. However, the full impact of the project was not fully realised for reasons that were beyond the control of the Australian and Chinese researchers.

The major impact in India has been the adoption of the purchase of longer wools, which has brought technical and economic benefits. The benchmarking of Indian mills' performance against global best practice gave an important impetus to mill improvement in reducing damage during dyeing and more cost-effective wool specification.

Capacity building and scientific impacts

Under the direct influence of the project, partner universities have developed strong collaborations with the Chinese wool industry and applied for a number of state and provincial projects. In 2001, XPU and Lanzhou Sanmao were awarded one of the six major national wool-research projects for the application of spinning-prediction technology for domestic wool, with grants of RMB2 million in cash and RMB14 million in interest-free loans. This project, entitled 'Prediction and control of product quality in topmaking and spinning', in 2004 won the highest award of the Chinese Textile Industry Science & Technology Advances program.

Promoting spinning prediction technology: Dr Shouren Yang (CSIRO Australia) holds a technical seminar for postgraduate students at Xi'an Polytechnic University, May 2007.

The two partner universities play an important part in textile education in China. Under the direct influence of the project they have established collaborative relationships with major Chinese mills, which have enhanced their capability to carry out industry-related research.

The project has trained university staff who were directly or indirectly involved in the project and, through them, younger-generation students. University staff at XPU claimed that they have learned scientific attitudes and methods of project planning through participation in the project.

The project has greatly strengthened the linkage between university teaching and research activities and industry practice. Processing prediction and quality control have been introduced into university as important areas for teaching, research and consultation. Many postgraduate students have received training in this area and made good progress in their studies and career development.

As stated by a project-sponsored PhD student at DHU, 'the project has built a bridge between the university and the industry, which has facilitated the cooperation between the two parties and helped to transfer research fruit to daily production quickly'.

As a direct result of the project, quality control and spinning prediction have become hot topics for postgraduate studies at the partner universities. Encouraging progress has been made in advancing the technology. The knowledge and skills gained through their direct or indirect involvement in the project will help their future career development.

In summary, the most important impact comes from the introduction of objective measurement, quality-control techniques and processing prediction into the Chinese and Indian wool industries. Secondly, benchmarking mills against world's best practice has produced a powerful stimulus for mills to improve their quality-management system in the course of catching up with the world's best practice. We believe the above two outputs have led and will continue to lead to improvements in quality and efficiency, that will allow the mills to more readily compete in global markets. It is also crucial for the continued expansion of employment opportunities and conditions in the partner countries' textile industries.

Leucaena management in West Timor and Cape York (AS2/2000/157)

Max Shelton

Project number	AS2/2000/157
Project name	Leucaena management in West Timor and Cape York
Collaborating institutions	Australia: University of Queensland Indonesia: Balai Pengkajian Teknologi Pertanian (BPTP); University of Nusa Cendana (UNDANA); Udayana University, Bali
Project leaders	Associate Professor Max Shelton and Dr Jacob Nulik
Duration of project	1 January 2001 – 31 December 2003
Funding	$428,718
Countries involved	Indonesia and Australia
Commodities involved	Beef cattle
Related projects	FST/1994/033

Motivation for the project and what it aimed to achieve

An applied research and development project was implemented in the Amarasi subdistrict and North Central district (TTU) of West Timor, Indonesia to improve the sustainability and productivity of cattle-production systems through improved feeding and husbandry.

In Amarasi, cattle fattening based on *Leucaena leucocephala* (leucaena) forage has been the major economic activity for the past 35 years and is the main source of cash income for smallholder farmers. In TTU, cattle are raised predominantly under an extensive grazing system on native grasslands, to produce store cattle for sale into the more intensively managed areas such as Amarasi.

The project involved collaborative partnerships between Balai Pengkajian Teknologi Pertanian (BPTP in West Timor and Lombok), the University of Nusa Cendana in West Timor and the University of Queensland. Udayana University in Bali and the Research Institute for Animal Production in Bogor played minor roles, were not visited and consequently their project activities are not reported.

Project activities in Indonesia were:

- socioeconomic surveys in Amarasi and TTU to determine key aspects of feeding and cattle management in both regions
- evaluation of new and existing forage tree-legume germplasm and study of vegetative propagation and seed production of the best accessions
- GIS-based examination of biophysical and socioeconomic attributes of the Amarasi system and of the potential to promote the system elsewhere in NTT
- training courses and field days to promote adoption of improved technology.

Feeding leucaena to cattle in Amarasi prior to sale to Kupang.

The activities in Australia were:

- research to determine the water-use efficiency (WUE) of key forage tree-legumes and management options to improve dry-season leaf production
- evaluation of leucaena management on rehabilitated land at the Comalco bauxite mine in Cape York
- investigation of the potential for use of leucaena pasture areas for live cattle exports that would provide a business opportunity for traditional owners in the region.

What the research project produced

The Amarasi and North Central Timor systems

We found that the Amarasi system was a commercially oriented, highly productive and sustainable method of cattle fattening. We found that there were feed quality and quantity limitations in the dry season but these could be overcome through adoption of the highly productive KX2 leucaena hybrid and *L. leucocephala* cv. Tarramba as components of the improved management approach being promoted by BPTP.

In TTU, the production system was predominantly extensive, with minimal management of cattle or feeding. Cattle ownership was associated with social status, with less emphasis on commercial production; cattle numbers were more important than cattle condition and, consequently, rangelands were being degraded due to overgrazing by cattle.

Economic analysis of several scenarios in both regions highlighted the excellent profitability (by local standards) of the Amarasi-style tethering and fattening systems compared with the poor profitability of free-grazing systems used in TTU.

Climatic and edaphic similarities between Amarasi and TTU indicated no biophysical constraint to the adoption of leucaena-based cattle-production systems in TTU. Limitations to adoption were socioeconomic factors related to the different feeding systems employed (free grazing instead of tethering), non-commercial attitudes to cattle raising and lack of access to higher-value markets.

We found that with regular visits to selected villages in TTU for cattle weighing and education of farmers, adoption of tethering, improved feeding and cattle management was possible. Where adoption occurred, farmers achieved improved growth rates and higher weaning percentages. Greater use of tree legumes and other forages close to the tethering areas was a key feature of this enhanced productivity.

Strong support from the district Bupati (policy and funding) and from Dinas Pertinakin (in-kind) cooperatively linked the government agencies with clan leaders and farmers. We found that adoption of technology occurred where progressive village leadership was (a) supported by district and provincial governments, (b) received technical information for improved husbandry and feeding management and (c) received support for improved marketing.

New germplasm

The evaluation of forage tree-legumes showed that:

- new leucaenas, such as the KX2 hybrid and cv. Tarramba, out-yielded other existing forage trees and could be recommended as a valuable addition to forage banks for wet-season and early dry-season feeding in NTT.

Vegetative propagation of KX2 was successfully undertaken at Cendana University and seed production of cv. Tarramba was commenced at BPTP Lily Station.

GIS mapping

- GIS mapping indicated that most of East Nusa Tenggara province, with its tropical climate and soils of neutral to alkaline pH, was suitable for growing *Leucaena* spp. Socioeconomic factors such as location of animal populations and interest of farmers in commercial cattle raising were the most important determinants of where adoption of the technology was most likely to occur.
- The full potential of GIS mapping for planning areas suited to forage tree-legume development was not realised. We recognised the need to digitise soil and socioeconomic data to increase the precision of mapping.

Maximising water-use efficiency of forage tree-legumes

Our work on WUE showed the following:

- KX2 and cultivar Tarramba, the new varieties of leucaena, showed good WUE in Timor. WUE was improved by late wet- or early dry-season harvesting of edible forage as this reduced water use and leaf shedding later in the dry season.
- In Australia, competition from the associated grass in a hedgerow system severely reduced WUE of leucaena. Methods to reduce competition were suggested.

Grazing leucaena at Weipa

Our grazing trials at Weipa showed that:

- very good live-weight gains were possible from cattle grazing leucaena thickets on mined land at Weipa after mechanical treatment to make it accessible to stock
- the leucaena thickets cannot be satisfactorily eradicated by cattle grazing alone, due to high costs, and would therefore need long-term management
- there was much interest in Cape York concerning the potential for use of leucaena–grass pastures on the Comalco site as holding facilities for live cattle to be exported out of Weipa
- leucaena pastures had the potential to provide business opportunities and employment for traditional owners in the region.

Strategies for use of the rehabilitated mined lands were discussed at a land-relinquishment criteria workshop held in July 2003.

A leucaena cv. Tarramba plot for seed production and cattle fattening; photo shows 3 months' dry-season growth.

Capacity building

The capacity of our collaborative partners was enhanced by (a) frequent formal meetings in Bali, Australia and Timor to discuss and provide feedback on work activities, (b) training courses and field visits provided for farmers from Amarasi and TTU and (c) higher-degree training provided to BPTP staff member Esnawan Budisantoso and Comalco staff member Mr Ian Little.

Adoption—how the project outputs are being used

The project was primarily designed to provide information on the limitations and opportunities for enhanced cattle production in Timor. Extension activities were not a major component of this project although field meetings of farmers were held, primarily in TTU. Indeed, a follow-up participatory extension program designed to achieve scale-up of successful technology was the main recommendation arising from the project. The principal capacity achievement was the development of Dr Esnawan Budisantoso into a highly competent and well-organised research scientist in BPTP NTT. He has become the principal collaborator with international groups, especially ACIAR. The following were specific adoption achievements:

- There was recognition of the superior value of the introduced cultivar Tarramba, leading to strong unmet demand for seed. Both BPTP and Dinas Perternakan have established seed orchards of this cultivar and are distributing seed.
- The hybrid variety KX2, on the other hand, has not been successful. Due to propagation difficulties, large-scale vegetative production of cuttings has not been achieved.

Impact—the difference the project has made or is expected to make

The use of more productive trees for forage in NTT has significantly improved the productivity of cattle in Amarasi and TTU. *Leucaena leucocephala* (leucaena) is the principal species responsible for improving supply of fuelwood, reversing land degradation, and lifting the economic returns to and social welfare of the rural families.

The technology that has been developed is mature, relevant and ready for large-scale adoption. It is now critically important that the opportunity for realisation of this potential be grasped for the benefit of farming communities in NTT.

However, the project reviewed has had only a small impact to date, as this was not the main focus of the program. The full potential benefits of the R&D outcomes of this project will not be realised until significant scale-up of the technology occurs and there is wider transfer and adoption of the technology beyond the boundaries of the project.

The long-term indicators of the future demand for beef are currently good and there is no reason to expect a major change such as a sudden diminution of demand.

Since uptake of leucaena technology is very strong in Australia, working with farmers feeding leucaena in Timor has strong parallels with similar activity in Australia. There is strong synergy between the use of leucaena in Timor and in Australia. For this reason, participatory R&D in Timor provides knowledge and lessons relevant to Australian farmers and vice versa. There are thus strong benefits from this project for the northern Australian cattle industry.

An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta (ASEM/1995/119)

Donna Brennan

Project number	ASEM/1995/119
Project name	An evaluation of the sustainability of farming systems in the brackish water region of the Mekong Delta
Collaborating institutions	▪ Australia: University of Sydney, CSIRO Marine Science, University of Western Sydney, Australian National University ▪ Vietnam: Can Tho University; University of Agriculture and Forestry, Ho Chi Minh City; Sub Institute of Water Resources, Southern Institute of Water Resources Research; Geological Survey of Vietnam ▪ Philippines: International Rice Research Institute
Project leaders	Donna Brennan, Nigel Preston and Vo Tong Xuan
Duration of project	1 July 1997 – 31 December 2002
Funding	$1,172,350
Countries involved	Australia and Vietnam
Commodities involved	Rice, shrimp

Related projects	■ FIS/1994/012 – Mixed shrimp farming – mangrove forestry models in the Mekong Delta ■ FIS/1994/011 – Prawn health management and disease control to sustain hatchery and pond production systems ■ SP843 – Investigation of the key researchable issues in the sustainability and productivity of coastal shrimp aquaculture in Thailand

Motivation for the project and what it aimed to achieve

The rapid adoption of rice–shrimp farming in the Mekong Delta during the late 1980s led to widespread concern about the sustainability of the farming practice. These concerns were partly motivated by the general environmental problems experienced in shrimp-production systems in Asia, but also by emerging issues experienced under local conditions. These included concern about the potential salinisation of rice fields following inundation of saline water during the dry-season shrimp cycle; concern stemming from evidence of land loss associated with sediment build-up on farms; issues associated with sourcing seedstock; and concern about the financial sustainability of the rice–shrimp farming system.

The project aimed to investigate the sustainability issues using on-farm field experiments and economic analysis. The emphasis of the field work was to determine appropriate on-farm management strategies to enhance the economic sustainability of the practice. The interdisciplinary nature of the project involved collaboration between eight organisations in Australia and Vietnam, as well as the International Rice Research Institute. A strong emphasis was placed on local collaboration, with farmers and provincial government officials taking an active role throughout the project.

What the research project produced

The project found that rice–shrimp farming could be a sustainable practice and recommended a range of management practices to ensure its environmental and economic sustainability.

Research on the rice component identified a variety suited to salinised field conditions, quantified the relationship between salinity stress and yield at different stages of the phenological cycle, and quantified a model of soil-water salinity in the rice–shrimp field. It was found that there was sufficient leaching of salts during the wet season to avoid a build-up of salt in the soil in the My Xuyen district of Soc Trang province.

Research on the shrimp component identified feeding strategies for shrimp stocked at different intensities, characterised pond water quality in the shrimp cycle and recommended a range of management strategies to improve shrimp survival and growth. These included the use of sediment ponds, shrimp-pond preparation, the practice of low water exchange, and strategies to improve early stage survival of post-larvae. The prevalence of white spot virus was identified as a key issue, and PCR technology was introduced to Can Tho University to assess white-spot status of post-larvae and broodstock.

A socioeconomic profile of farm households and farming practices was developed that identified a wide variety of shrimp-production practices and large differences in economic performance of farms. The information was used to inform the design of the second-year experiments that emphasised water exchange and prompted an emphasis on natural biota as shrimp feed in the low-input systems in the Gia Rai district of Bac Lieu province.

Economic models were developed to assess issues relating to environmental sustainability (particularly sedimentation) and economic sustainability associated with farm financial risk. It was demonstrated that rice – *Peneaus monodon* systems were economically sustainable, but that rice – natural shrimp systems were not.

Collaborators at Can Tho University were exposed to new techniques in shrimp science and economic analysis. Collaborators in the provincial governments and at the farm level gained new knowledge about the benefits of rice – *Peneaus monodon* systems and best management practices.

The project produced two PhD degrees in economics, a Masters degree in shrimp science, a Masters degree in soil science, and a Masters degree in agricultural economics.

Adoption—how the project outputs are being used

Two factors led to high uptake of rice–shrimp farming (and recommended shrimp practices) in the region. These were the substantially higher profits attained compared with traditional rice monoculture, and the interest and promotion by local leaders from the agriculture and fisheries departments. The research finding of the project—that rice–shrimp farming is sustainable—has underpinned the active participation

Harvesting the rice in a rice–shrimp field, My Xuyen district, January 2008.

of the local government officers in promoting the system. The fact that these local leaders were so closely involved throughout the project (participating in every project workshop and the initial focus groups, and supporting the experimental work at the farm level) contributed to this positive outcome for the project.

The project produced extension material for better shrimp management that was disseminated to farmers in the region. To a large extent these improved practices have been adopted, although in Soc Trang province the integrated rice–shrimp practice has been dropped in favour of intensive shrimp monoculture. Project scientists had expressed some concern over the potential environmental and economic sustainability issues associated with more-intensive shrimp farming. The exposure of provincial government officers to the project has meant that they are continuing to try to discourage monoculture and encourage a return to rice–shrimp farming, and are working on rice varieties to improve productivity.

Research results on the sustainability of rice – *Penaeus monodon* prompted a major undertaking by the Bac Lieu provincial government to provide a suitable water-management regime for rice–shrimp culture in Hong Dan, Phuoc Long and Gia Rai districts. The operation of sluice gates allows the control of water salinity throughout the year and provides saline water in the dry season and fresh water in the wet season in 20,300 ha of farmland. There is believed to be 100% adoption of rice–shrimp culture in this area. The shrimp-management practices recommended by the project have been included in extension material provided to the farmers in this new rice–shrimp area.

Uptake of project results, in particular the shrimp-husbandry practices, is attributed to the clear economic incentives for improving survival and growth in the shrimp cycle, and the active steps taken to promote adoption. The earliest adoption was through the on-farm research collaboration, where a leading farmer

Aeration equipment used to support high stocking rates in a shrimp monoculture pond. This farm was previously a rice–shrimp farming pond but the field has been dug out to provide a deeper pond for shrimp monoculture.

A polder in the newly developed rice–shrimp farming area of Gia Rai district.

was selected to provide the experimental site, was trained intensively in farming techniques during the experimental period and later became a source of advice for other farmers. Subsequently, the project developed extension material that was promoted to farmers, and since that time the collaborating Vietnamese institutions (Can Tho University and the district government offices) have provided ongoing training workshops and updated extension material.

The Fisheries Department at Can Tho University has now widely adopted the use of data loggers to enable detailed investigation of aquaculture water quality in field research, a technique that was first introduced by the project. The department has used the PCR technology introduced there not just for research but also as a service to the community.

The two PhD scholars from the project (Tran Thanh Be and Le Xuan Sinh) have returned to senior positions at the university with a stronger basis in economic analysis and the integration of economics and science. Both Vietnamese Masters scholars are now studying for doctorates.

Impact—the difference the project has made or is expected to make

As the rice–shrimp system was a relatively new practice, little scientific knowledge was available about the salinity dynamics in the field, performance of rice varieties, water quality and nutrient availability in the shrimp pond. The research conducted under the project provided a substantial contribution to knowledge. Anecdotal evidence suggests that the best management practices for shrimp culture that were developed by the project have been widely adopted. Improvements in survival associated with better shrimp management have undoubtedly occurred but it is difficult to quantify these because many farmers have

Dr Tran Thanh Be with Mrs Luu, the winner of Soc Trang Provinces 'best rice crop in rice–shrimp system' award, designed to encourage interest in rice farming. The backdrop is an advertisement for shrimp feed.

changed to intensive shrimp culture which the project (and management practices) was not designed to address. Survival in intensive shrimp ponds appears to be relatively poor, so data at aggregate level cannot be used to infer benefits of improved survival in the rice–shrimp system.

Substantial income benefits associated with rice–shrimp have been observed in the new 20,000 ha area developed for rice–shrimp culture in Bac Lieu. The annual income benefit to farmers in this region alone is around A$35 million. However, this benefit must be attributed to a number of investments besides the ACIAR project, including the International Rice Research Institute water-management project, infrastructure modification and ongoing extension activities in the province. Nevertheless, the ACIAR project was the initial driver for all the subsequent activities, and probably had the most influence in terms of verifying the sustainability of the practice.

The project did not focus on shrimp monoculture, although it was of some concern during our activities. It is possible that the success of the project—in promoting better shrimp-production practices— indirectly encouraged the adoption of shrimp monoculture. For example, the collaborating farmer in My Xuyen became so successful at shrimp farming in the rice–shrimp operation that he thought he could improve his income by converting to intensive shrimp monoculture.

It is likely that intensive shrimp monoculture is creating adverse environmental impacts in the region.

Conservation, evaluation and utilisation of plant genetic resources from the Central Asian republics and Caucasus (CIM/2000/078)

Clive Francis

Project number	CIM/2000/078
Project name	Conservation, evaluation and utilisation of plant genetic resources from the Central Asian republics and Caucasus
Collaborating institutions	▪ Syria: Genetic Resources Unit, International Center for Agricultural Research in the Dry Areas (ICARDA) ▪ Australia: Centre for Legumes in Mediterranean Agriculture (CLIMA), University of Western Australia; Australian Winter Cereals Collection (AWCC), NSW Department of Agriculture; Australian Temperate Field Crops Collection (ATFCC), Department of Natural Resources, Victoria ▪ Research institutions in Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Uzbekistan
Project leaders	Dr Jan Valkoun (ICARDA), Dr Ken Street (ICARDA) and Professor C.M. Francis (CLIMA)
Duration of project	1 July 2001 – 30 June 2004
Funding:	$476,100
Countries involved	Armenia, Australia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Syria, Tajikistan, Turkmenistan, Uzbekistan.

Commodities involved	Grain and pasture legumes; cereals—wheat and barley; wild relatives of wheat, chickpea and lentil
Related projects	CS1/1993/817, CS1/1997/056, AS1/1998/026, GRDC: UWA-308. International linkages for plant genetic resources.

Motivation for the project and what it aimed to achieve

The project aimed to build on the linkage established between ICARDA and Australian Genetic Resource Centres. To this liaison the project would add strong links to the renowned Vavilov Institute in St Petersburg, Russia, home of the father of plant genetic resources Nikolai Vavilov, and countries in the Central Asian and Caucasian network established by ICARDA. The project was considered timely in Central Asia where the native genetic diversity is being eroded. This is due to intensification of agriculture without adequate inputs or crop husbandry, overgrazing of non-cropped land, deforestation, industrialisation and amelioration of the soil. These factors have adversely affected the agroecosystem of the region. A valuable component of the farming system is the prevalence of land races and old native cultivars of cereal and legume crops. This is because in countries such as Armenia, Georgia, Turkmenistan, Uzbekistan, Tajikistan and Kyrgyzstan, many of the numerous subsistence farmers are still using local cultivars, which are gradually being replaced by current commercial cultivars. This process is expected to gather momentum in the coming years as the national programs attempt to meet the demand for food security and insist on the use of high-yielding but less stable varieties.

Germplasm in the region was previously collected by Vavilov Institute scientists when these countries were part of the former Soviet Union. The emphasis was on major field crops and horticultural crops, with little or no coverage of the wild relatives of major crop species. Additionally, there is a major worldwide concern for the security and availability of germplasm in the Vavilov collections. CLIMA and ICARDA have received funding from Australia's Grains Research and Development Corporation (GRDC) for a special project (UWA308) to investigate what can be done to remove this concern. In doing so there are spin-off benefits to this ACIAR-funded Central Asia – Caucasus (CAC) project in that germplasm will again be freely available to the CAC states. In addition, the highly skilled Vavilov Institute staff, who are experienced plant collectors and botanists, are keen to accompany the collection missions. This adds greatly to the missions' capacity and provides a cross link with the GRDC Vavilov project.

What the research project produced

The progress to date has been consistent with the project aims:

1. This major initiative has coupled the ICARDA-network countries with the Vavilov Institute to complete an Australian-linked genetic-resource network unparalleled in the past.
2. Through the network, access has been gained to the regions with the richest sources of crop and forage germplasm and the host countries have been helped to improve their germplasm base.
3. The linkage with ICARDA has facilitated germplasm exchange, strategic collection missions, offshore screening and characterisation of the germplasm prior to importation into Australia.

The partnership between CLIMA, ICARDA and the Vavilov Institute has seen perhaps the greatest-ever single influx of crop-plant germplasm into Australian collections. In 2002 and 2003 alone more than 6,000 accessions were landed in Australia. The Australian Temperate Field Crops collection at Horsham, Victoria, has received over 1,000 lines of chickpeas and relatives as well as almost 1,000 of lentils, peas and faba beans. The Winter Cereals Collection at the Agricultural Research Centre, Tamworth, NSW, will, after quarantine, lodge some 1,300 barley and more than 2,500 wheat and relatives (including 1380 durum wheats) in the national collection. All the lines were characterised and classified at ICARDA with the aid

Dr Tamara Smekalova, botanist and herbarium specialist from the Vavilov Institute (VI), St Petersburg, during a collecting trip for wild crop-plant germplasm at a historical site in Armenia. The link with VI is important for the project's success.

of specialist staff from the Vavilov Institute. This project, together with the GRDC-funded project, adds a new dimension to Australian breeding programs because, in the main, the accessions were land races and sourced from regions of the world such as the Central Asian republics whose genetic base is little represented in Australian cultivars.

Plant collection tours have backed the introduction program. They have in many cases 'followed the footsteps' of Vavilov himself and provide plenty of evidence of the serious genetic erosion taking place in these unique regions of the world. Most recent missions, with the assistance of the concurrent GRDC project, have covered most Central Asian and trans-Caucasian countries—Armenia, Georgia, Azerbaijan, Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan. The exception is Afghanistan. These collections, the most extensive ever undertaken with Australian support, were made possible only through the Central Asian and Caucasian genetic resources network developed by ICARDA. This network was established largely through the outstanding efforts of Dr Ken Street, an Australian scientist who is now curator of grain legumes at ICARDA. He provides a most important link for Australia and one established with ACIAR support.

The collections themselves were greatly aided by the skills and experience in the regions of the accompanying Vavilov Institute scientists. Pasture specialist on many of the tours was Dr Nikolai Dzybenko, now Director of the Vavilov Institute—a wonderful linkage indeed.

The seed stores of village women are an important source of land-race varies. Ms Natalya Rukhkyan collecting samples at a village in Armenia.

Adoption—how the project outputs are being used

The imports into Australia have largely been in the form of germplasm for use by the plant breeders rather than for direct use by farmers. It is thus a project largely with longer-term benefits to Australian agriculture. Benefits to Australia from the close liaison with ICARDA are many. ICARDA has a world mandate for research on barley, lentil, faba bean and their wild relatives and progenitors, and shared mandates with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for Kabuli chickpea and the International Centre for Maize and Wheat Improvement (CIMMYT) for bread and durum wheat and wheat wild relatives and progenitors. ICARDA also cooperates closely with the International Plant Genetic Resources Institute (IPGRI) in the conservation of the plant genetic resources of Central and West Asia and North Africa (CWANA) and hosts IPGRI's Regional Program for CWANA.

Although essentially a long-term project some shorter-term benefits have accrued. In most recent times, ICARDA has made available over 500 lines of faba beans resistant to chocolate spot and Ascochyta, more than 200 ICARDA lines of chickpea tested for resistance to Ascochyta, breeding lines of lentil (released as Cassab and Cumra) and *Lathyrus cicera* (released as Chalus), and has assisted in offshore screening of peas and lupins. Additional benefits will accrue from wider access to the barley and wheat collections and those of the wild relatives of legumes and cereals. Both ICARDA and Australia have well-developed breeding programs that can readily utilise introduced germplasm and transfer partly selected forms to the host countries.

Dr Colin Piggin of ACIAR, Dr Ken Street of ICARDA and Professor Clive Francis discuss project details in Uzbekistan at the start of the plant genetic resources project.

Impact—the difference the project has made or is expected to make

The major immediate impacts are the strong linkages developed with ICARDA and the Vavilov Institute. It was essentially through these links, and a strong genetic resource program generally, that Australia has become a major partner in the world Global Genetic Resources Trust. Australia has been the major donor to the Trust and Dr Street is a consultant to it.

The project and the initiatives of ICARDA and CLIMA with ACIAR have greatly strengthened linkages with CAC countries and have been instrumental in the creation of a very professional web page created by Ms Natalia Rukhkyan of Armenia. This details personnel and facilities linked to plant genetic resources in all the countries receiving ACIAR project support.

Many developing countries possess a significant amount of genetic resources, but are concerned that they receive little or no return on the technologies or products that may be developed from these resources. Consequently, developing countries are becoming increasingly sensitive about the removal of their plant genetic resources. ICARDA has established long-standing relationships with national programs, which have been instrumental in allowing collections in Ethiopia, India, Turkey, Ecuador, Russia and the Central Asian republics and Caucasus. ICARDA has ensured that the countries concerned benefit from the results of these collections. This is most readily done through the ICARDA gene bank, which now houses one of the world's leading germplasm collections. The germplasm collected is kept both by the host country and stored 'in-trust' in ICARDA's gene bank, providing 'safety net' duplication. Aided by external projects, such as that from ACIAR, ICARDA provides to the participating countries all information and analysis pertaining to the germplasm collected, and supplies related, potentially useful germplasm from its gene bank. This includes improved material that may be developed from the material collected from those countries.

Bioherbicide development for cereals in integrated weed management (CP/1998/018)

Bruce Auld

Project number	CP/1998/018
Project name	Bioherbicide development for cereals in integrated weed management
Collaborating institutions	▪ Australia: NSW Agriculture ▪ Vietnam: National Institute of Plant Protection, Hanoi; Cuu Long Rice Research Institute, Omon, Cantho
Project leaders	▪ Professor Bruce Auld ▪ Professor Dr Ha Minh Trung
Duration of project	1 July 1999 –30 June 2002; extension 1 July 2002 – 30 June 2004
Funding	$462,163
Countries involved	Vietnam and Australia
Commodities involved	Rice and wheat
Related projects	CS2/1994/002 – Biological control of grassy weeds with fungi as bioherbicides

Motivation for the project and what it aimed to achieve

Although a range of selective herbicides is available for wheat and rice, their continued use is leading to the development of herbicide resistance and pollution of the environment. The use of naturally occurring fungal pathogens as bioherbicides is an attractive alternative to chemical control for specific weeds. Research and development of bioherbicides involves weed science, plant pathology, microbiology and formulation chemistry. It is thus an excellent tool for developing a range of technical skills and collaboration among researchers.

The project arose from project CS2/1994/002 – Biological control of grassy weeds with fungi as bioherbicides, implemented in Vietnam and Australia. This project identified the major grass weeds in rice in the Mekong Delta in the south and the Red River Delta in northern Vietnam. Subsequently, extensive field surveys of diseases of these weeds were made. Fungi isolated from infected plants were assessed as potential bioherbicides. Fungi specific for the two major grass weeds in Vietnam were found. In Australia, a pathogen was found for wild oats, the worst weed in wheat.

Weed scientist Ms Nguyen Thi Tan (left) and technician Ms Tran Thi Thu working with the weed collection in the herbarium at the National Institute of Plant Protection, Hanoi. Ms Tan coordinated the first systematic survey of weeds of rice in the Red River Delta as part of the project.

Dr Duong Van Chin, Cuu Long Rice Research Institute, examines plants treated with a bioherbicide formulated from an indigenous fungus. Junior researchers Tran Thi Kieu (left) and Duong Pham Minh Chau (middle) look on. Dr Chin was the project leader in South Vietnam.

What the research project produced

Greenhouse experiments confirmed the potential for the fungus *Exserohilum monoceras* to control barnyard grass, *Echinochloa crus-galli*, but large-scale field experiments in the Red River Delta demonstrated that the fungus was not sufficiently virulent to control the weed. In southern Vietnam, the fungus *Setosphaeria rostrata* was effective in greenhouse and small-scale field experiments in controlling red sprangletop, *Leptochloa chinensis*. However, mass production of the fungus was not developed beyond laboratory scale and formulation improvement would be required for application to large areas.

In Australia, glasshouse experiments showed that the fungus *Drechslera avenacea*, although producing lesions, could not kill wild-oat plants, *Avena fatua*. An extensive survey for potential bioherbicides of the other major grass weed of wheat, annual rye grass (*Lolium rigidum*), failed to discover any suitable candidate organisms.

Dr Nguyen Hong Son, weed scientist at the National Institute of Plant Protection, Hanoi, at a field site in the Red River Delta. Dr Son completed his PhD while working on the project.

Adoption—how the project outputs are being used

In Australia, the project has demonstrated that there are no potential bioherbicides for the two main grass weeds of wheat. This finding is adopted in the sense that researchers are thus guided to other avenues for management of these weeds.

In Vietnam, while research on formulation of *Setosphaeria rostrata* to control red sprangletop continues at the Cuu Long Rice Research Institute its ultimate practical development appears unlikely. This is because of lack of large-scale, mass-production technology and the existence of competing chemical herbicides. Although the fungus found in the Red River Delta for barnyard grass control was not successful, a bioherbicide product for this weed has been under development in Japan and may become a commercial product.

Impact—the difference the project has made or is expected to make

The project introduced biological control of weeds into Vietnam and enhanced the capacity of two scientific institutions to undertake major weed-research projects and plant-disease surveys. Skill development among the researchers in this project has probably been the major impact of the project. Most of the Vietnamese scientists involved in the project visited Australia at least once during the period of this and the earlier project. As the research in Australia was on a grass weed in a grass crop and the fungi were similar, the Australian work provided a model for the visiting scientists at a hands-on level.

The magnitude of carryover impacts of this project is dependent on the extent to which the cooperating researchers have benefited from the work. As several of the original cooperating scientists have been promoted into research management, it is likely that their influence will be significant.

More efficient breeding of drought-resistant peanuts in India and Australia (CS1/1997/114)

R.C.N. Rachaputi

Project number	CS1/1997/114
Project name	More efficient breeding of drought-resistant peanuts in India and Australia
Collaborating institutions	▪ Australia: Queensland Department of Primary Industries and Fisheries (QDPI&F) ▪ India: Indian Council of Agricultural Research (ICAR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Project leaders	G.C. Wright (QDPI&F), M.S. Basu (ICAR), R.C.N. Rachaputi (1998–99) and S.N. Nigam (1999–2001) (ICRISAT)
Duration of project	1 July 1998 – 31 June 2001; extension 1 July 2002 – 31 December 2003
Funding	$ 591,423 (including extension phase)
Countries involved	Australia and India
Commodities involved	Peanut (groundnut)
Related projects	CS1/1992/016 – Selection for water-use efficiency in grain legumes

Motivation for the project and what it aimed to achieve

Drought is a major constraint to peanut productivity in many regions of the world, including India and Australia, where peanut is grown under dryland conditions. While breeding of more drought-resistant genotypes by direct selection for yield can be effective for a given target environment, the limitations of this approach are high resource investment and poor repeatability of the results due to the large genetic – environment (G × E) interaction for yield. Plant breeders and physiologists believe that more rapid progress can be aided by a prior knowledge of the physiological basis of crop performance under drought conditions.

Although work done at ICRISAT and Australia revealed significant variation for the three traits—transpiration (T), transpiration efficiency or water-use efficiency (WUE), and harvest index (HI)—that were proposed by Passioura (1986)[1] to explain yield variation in water-deficit environments, the application of this physiological model in peanut-breeding programs has not been possible because of practical difficulties associated with measurement of the traits under field conditions.

1 Passioura J.B. 1986. Resistance to drought and salinity: avenues for improvement. Australian Journal of Plant Physiology 13, 191–201.

A Gujarat farmer group discusses aspects of peanut seed crop management with project staff. Gujarat farmers have selected for adoption four peanut varieties developed from the ACIAR project and a program of rapid seed production is underway.

Work done in precursor ACIAR project CS1/1992/016—Selection for water use efficiency in food legumes—had developed low-cost, rapid and easily measured surrogate measures for each of these traits, thus allowing their potential quantification in the large germplasm collection available at ICRISAT and in Indian breeding populations. Project CS1/1997/114 therefore aimed to implement and apply this physiological knowledge to test whether indirect selection using the trait approach could improve the efficiency of selection in large-scale peanut-breeding programs involving breeders, physiologists and modellers in a truly collaborative research program between QDPI&F, ICRISAT and ICAR. New breeding approaches utilising physiological traits (T, W and HI) have been proposed to improve the understanding and efficiency of selection for superior drought-tolerant genotypes. The project used a crop analytical model proposed by Passioura (1986), viz.

$$\text{pod yield} = \text{water transpired (T)} \times \text{water-use efficiency (W)} \times \text{harvest index (HI)}$$

to analyse pod-yield variation under water-limited conditions in three functional components.

The project CS1/1997/114 began in 1998 with the selection of elite parents possessing high levels of drought-resistance traits, as identified with the trait-based selection approach generated in CS1/1992/016.

What the research project produced

The research project resulted in several technical outputs as summarised below:

- The research found that both indirect selection (trait-based) and direct selection methods for yield were able to select out high-yielding genotypes under water-limited/non-limiting conditions. Their yields were significantly higher than local check varieties (e.g. from 10–30% higher, depending on location), suggesting that parental selection is more critical than the breeding methodology followed.
- Although there were small differences in the efficiency of selection (i.e. rate of genetic progress) between trait-based and empirical approaches, there was clear evidence that the trait approach was able to identify high-yielding genotypes with high levels of WUE, which it can be assumed must have yield benefits in environments subject to extreme water stress.
- Standardisation of SPAD chlorophyll meter measurements to minimise environmental effects resulted in increased heritability of the *W* term in the Passioura equation. This led to extensive application of SPAD measurement to screen for WUE in peanut-breeding programs in India.
- In Australia, the project allowed import of short-duration drought-resistant germplasm from India for use in the local peanut-breeding program. It was arguable that the Indian germplasm used in the crosses was not the most suitable (i.e. Spanish type and short stature) under local agronomic conditions, and it was always going to be difficult to beat the locally adapted varieties such as Streeton and Conder, which have superior adaptation in our water-limited environment. However, development of short-duration genotypes proved to be beneficial to dryland environments as well as for use in coastal cane-farming systems.

Adoption—how the project outputs are being used

Current levels of adoption of outputs by initial and final users can be grouped under the following categories:

Adoption of technical outputs by researchers

Selection tools, especially the SPAD chlorophyll meter, are being extensively used at all collaborating centres as a surrogate measure for WUE in parental and progeny selection.

However, collaborating scientists acknowledged that they had not been using the 'selection index' approach developed in the project (which integrates the T, W and HI traits) because it was too laborious.

Collaborative research conducted with the University of Agricultural Sciences, Bangalore (UASB), on development of selection tools for drought-resistance traits in the precursor ACIAR project (CS1/1992/016), had a major influence on installation in 2000 of a national research facility by the Ministry of Agriculture, Government of India, to conduct research on the application of natural isotopes in crop-improvement programs. As a part of the mandate of the national research facility, UASB organised a number of training programs during 2002–07 for Indian National Agricultural Research System institutes, to raise awareness among crop scientists and research administrators about the trait-based approach for crop breeding that was originally introduced in the ACIAR (CS1/1997/114) project. As a result, a number of crop-improvement

'Walter' peanut variety is becoming a popular variety in cane rotation systems due to its early maturity, which fits in well with cane rotation. The photo shows 'Walter' planted during the 2008 season at Bundaberg ready for harvest at 110 days.

Production of certified seed of peanut varieties is being undertaken by progressive growers under supervision of project staff in Gujarat. Project staff visit the seed production blocks regularly and advise growers about seed crop management.

programs in India (e.g. peanut, soybean, rapeseed, mustard, sunflower and finger millet) are now currently using selection tools and methodologies developed in the original project (e.g. rain out shelters, carbon isotope discrimination, O^{18} analysis and SPAD meters).

Adoption of project outputs (varieties) by farmers through a farmer-participatory approach.

The promising varieties generated in the ACIAR project are being evaluated using a farmer-participatory model in Andhra Pradesh, Gujarat, Maharashtra and Orissa states under an ICRISAT–NRCG project commissioned by the Government of India. These farmer-participatory trials resulted in identification by growers of four improved varieties (ICR3, ICR4, JAL42, JUG 16) based more on better yield and quality performance than local checks. Farmers are undertaking seed increase of these varieties for further large-scale adoption in Gujarat and Andhra Pradesh.

Release of promising genotypes to growers for adoption under state-sponsored schemes

Collaborating universities (particularly Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh and Mahatma Phule Krishi Vidyapeeth, Maharashtra) have pursued further selection and release of the material developed in the project using funds from state-sponsored schemes. As a result, ANGRAU released a new variety TIR 25 ('Abhaya') in Andhra Pradesh in 2006, which it expected would cover large areas in the Chittoor district of Andhra Pradesh in the following 2 years. In the state of Maharashtra, a variety (JALW 02) is at pre-release stage. These releases represent an intermediate step before adoption of outputs by end users.

Varietal release through the national network system—All India Coordinated Research Project (Groundnut)

In order to disseminate the project outputs (varieties) to wider peanut-growing regions throughout India, the national network program (i.e. the All India Coordinated Research Project (Groundnut)) initiated a series of national drought nursery trials during 2004, in which a number of drought-resistant lines, including the varieties developed in the ACIAR project, were evaluated at 11 drought-prone sites throughout India. As a result of these trials, four varieties (ICR,24, ICR 48, ICR 09) developed in the ACIAR project have been selected for further evaluation in advanced varietal trials in 2009, followed by possible release at the national level.

Impact—the difference the project has made or is expected to make

In India, the impact of the project was evident by (a) continued adoption of selection tools for drought-resistance traits (particularly for TE) in peanut-breeding programs, (b) further selection and rapid dissemination of promising varieties to farmers through a farmer-participatory approach and the national and state network systems, (c) adoption of trait-based selection approaches by other food and plantation crop breeding programs and (d) enhanced ability and expertise of scientists to apply for and access large external-funding grants to pursue trait-based selection programs, including the search for molecular markers for drought-resistance traits in peanut and other crops.

Some major project impacts during the post-project phase have included the release of one variety (TPT 25) in 2007 in Andhra Pradesh, identification of a variety (JALW 02) for release in Maharashtra state, further identification of four drought-resistant genotypes (ICR 24, ICR 48, ICR 09) using a farmer-participatory approach for possible release in the states of Gujarat, Andhra Pradesh and Orissa, and possible release of one or two genotypes in 2008 at the national level under the All India Coordinated Research Project (Groundnut).

In Australia, this project has introduced a range of elite germplasm from India having high levels of drought-resistance traits (T, W and HI) as well as very early maturity, the latter assisting attainment of the project's additional objective of drought avoidance.

The project also resulted in improved understanding of the major traits associated with drought resistance in peanuts and development of 'easy-to-use' surrogate tools to select for these traits in the breeding programs. The Australian peanut-breeding program at Kingaroy has also used the Indian introductions and other germplasm, in conjunction with selection tools and drought-resistance breeding knowledge, in a rapid backcrossing program to introgress the high oleic fatty acid gene over the past 6 or so years.

The project has led to release in Australia of two drought-resistant peanut varieties (Walter and Middleton) for the Australian program. Although Walter was intended for use in dryland regions of Burnett, it is rapidly gaining ground in coastal cane-farming systems due to its shorter duration characteristics, which allow growers to return to the cane-cropping cycle up to 4 weeks earlier than with conventional varieties.

The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea (FIS/1998/024)

Steve Blaber

Project number	FIS/1998/024
Project name	The biology, socioeconomics and management of the barramundi fishery in the Fly River and adjacent coast of Papua New Guinea
Collaborating institutions	▪ Australia: CSIRO Marine Research, Cleveland, Queensland; James Cook University, Townsville, Queensland ▪ Papua New Guinea: National Fisheries Authority (NFA), Port Moresby; Ok Tedi Mining Limited (OTML), Tabubil
Project leaders	Dr S.J.M. Blaber, Mr P. Polon, Mr Charles Tenakanai and Dr M. Wood
Duration of project	1 July 1999 – 30 June 2002; extension 1 July 2002 – 31 December 2003
Funding	ACIAR A$699,491; Ok Tedi Mining A$525,000, CSIRO A$406,065
Countries involved	PNG and Australia
Commodities involved	Miscellaneous diadromous fish
Related projects	FIS1996/081; FIS2001/059; FIS2002/056

Motivation for the project and what it aimed to achieve

Barramundi is the most economically important species in the artisanal fisheries of Western Province, Papua New Guinea (PNG), with the largest stock in the Fly River region. Until the early 1990s, barramundi formed 80% of the catch in the coastal fishery and supported over 200 small-scale fishers. A similar artisanal fishery existed in the Fly River and its tributaries. Barramundi was the fourth most valuable export fishery in PNG, but collapsed in 1990 due to poor catches. At the start of the ACIAR project in 1999, the coastal artisanal fishery was continuing to decline with catches as low as 10 tonnes a year. This consisted mainly of juvenile fish less than 1 year old and a smaller quantity of adults. Regular surveys by Ok Tedi Mining Ltd (OTML) in the Fly River since 1984 also showed declining catches.

For the above reasons, rehabilitating the barramundi populations in Western Province had become an important issue, and CSIRO was approached in 1995 to undertake a preliminary study of the situation. An ACIAR-funded 1-year study by CSIRO and the National Fisheries Authority (NFA) (FIS/1996/081) had as its main objectives the collation and analysis of all the original commercial barramundi logbook data collected since 1970 and, with the cooperation of OTML, the amalgamation of these data with data collected by OTML since 1984 on barramundi in the Fly River.

The results of this small project indicated serious gaps in knowledge of many aspects of the fish's biology and the characteristics of the traditional fishery. In particular, there were conflicting reports on the state and delineation of the stocks, and the location of spawning areas.

Typical barramundi fishing site on the middle Fly River, Papua New Guinea.

The primary objective of this project was to develop for PNG a draft management plan for the barramundi fishery that was acceptable to all stakeholders. In order to develop such a plan, the main project activities were:

- to re-examine the biological basis for the current understanding of the life cycle of barramundi in PNG
- to identify the most vulnerable life-history stages that needed to be protected in order for the population to increase to such levels that would allow a sustainable fishery in the Fly River and along the adjacent coast
- to conduct socioeconomic surveys with the active and close involvement of local stakeholders to determine the importance of barramundi to the local economy.

What the research project produced

Technical outputs

There were two main technical outputs:

- Conclusive genetic and biological evidence demonstrated that there is only one stock of barramundi living in the Fly River and adjacent coastal waters. The stock extends into Irian Jaya, thereby constituting a cross-border resource, but differs from barramundi found in the far east of PNG. This was especially useful to management because, based on studies conducted in Australia, the expectation was that there would be more than one stock of barramundi in the fishery. This new knowledge meant that the fishery could be managed as a single unit stock.
- Biological studies showed no evidence of changes from 1970s estimates of parameters of growth, reproduction and feeding. However, otolith microchemistry data showed conclusively that the migration patterns of barramundi do not follow a regular pattern as they do in Australia. Many fish only visit the sea once during their lives and some individuals remain upriver for extended periods. A key factor then is that coastal and estuarine populations of barramundi form the majority of spawners, with little input from middle and upper Fly River fish. This has important fisheries management consequences because it indicates a necessity to minimise catches of large fish (spawning females) on the coast.

Policy outputs

A barramundi management plan was the ultimate policy output, but there were three intermediate outputs important to development:

- Reductions in the catch of large females could be achieved by restrictions on the use of large mesh gill nets (7 inches or greater) and these were included in the management plan.
- The completed bioeconomic model was demonstrated to project staff at the final project meeting in April 2002. NFA staff were trained in the application and use of the model for evaluating different management options.

- The socioeconomic study found that villages along the waterways had no indigenous knowledge or attitude that resources, in particular barramundi, are finite and must be managed for sustained yield. No local group had indigenous knowledge of the complex breeding and migratory habits of this species in waters claimed and fished by a long string of different villages and language groups. Although coastal villages and river clans claimed rights (contested by other groups) to exclude outsiders from waters over which they claimed tenure, no group had traditional resource-management practices that could form part of the management plan.

The Barramundi Fishery Management Plan developed by the project with the aid of four community consultation meetings involving the participation of all stakeholder and community groups was accepted by the National Fisheries Board in March 2003, signed into law on 15 April 2003 and Gazetted by the PNG Government on 16 April 2003. The plan involves net mesh-size restrictions as well as closed seasons and areas. Under the terms of the management plan, an Interim Barramundi Management Advisory Committee (BMAC) was set up in 2003.

A four-page coloured pamphlet about barramundi management was produced and distributed throughout Western Province.

Capacity developed by the project

Development of skills and knowledge included socioeconomic survey training to three OTML community liaison staff, and biological research training provided by CSIRO to two OTML and one NFA scientist. The NFA scientist was subsequently the recipient of a John Allwright Fellowship and undertook PhD studies on barramundi as part of the project.

Ok Tedi River showing bed aggradation cause by mining. Barramundi no longer occur here.

Development of research tools included training of NFA scientists by CSIRO in the use of a management strategy evaluation model for assessing different management options. This continued the long-term collaborative relationship between CSIRO and NFA and hence capacity building within NFA. The outputs of projects such as the present barramundi project contribute to NFA developing sustainable fishery-management plans.

Adoption—how the project outputs are being used

The key output was the new Barramundi Fishery Management Plan, which was supported by the series of technical and policy outputs outlined above.

Users of the Barramundi Fishery Management Plan

National Fisheries Authority

This is the PNG Government agency responsible for fisheries regulations. As such, it was responsible for adopting the plan drafted by the project, and seeing it through the various administrative and legal processes that led to it being gazetted into law in 2003, and the subsequent measures to ensure its uptake at industry and community levels.

Ok Tedi Mining Limited

The Environment Department of OTML adopted the recommendations of the project as specified in the management plan as the basis for continued monitoring of barramundi populations in the Fly River at Kwambit, Bosset and Ogwa. This monitoring provides the only independent data for assessing the status of barramundi populations

Ok Tedi Development Foundation (OTDF)

OTDF was formed in order to promote sustainable development in the mine-affected corridor of the Fly River and Western Province coast. OTDF has the community networks and logistic capabilities to enable the development of sustainable projects along the Fly River and adjacent coast. The site location choice and technical inputs for the OTDF-funded barramundi aquaculture project are at least partially dependent on data provided by the project and OTML monitoring.

The fishing companies based at Daru and Obo

The companies that buy most of the barramundi have fully supported and adopted the regulations specified in the management plan. The companies refuse to buy fish greater than 1 m in length or less than 36 cm, and do not supply or use nets with a mesh size of 7 inches or more.

Fishing village communities

The ways in which the many different fishing communities have adopted the outputs of the project vary depending on location and the relative importance of barramundi to them. Adoption of the new regulations by traditional fishers has been almost complete in areas close to commercial markets, and least in villages far from markets and in recent immigrants to the coast around Daru.

Adoption of technical and policy outputs

The Barramundi Fishery Management Plan, the ultimate vehicle for delivery of project results in terms of changing fishery regulations and influencing the sustainability of the fishery, was adopted into law in 2003. This plan also indirectly played a major role in influencing future planning for an aquaculture industry in Western Province.

Once the plan was gazetted, NFA and OTML followed up with a series of regional meetings in Western Province and produced (with the help of the project) a pamphlet that was widely distributed among fishing communities. There was a change in fishing practices following the promulgation of the new regulations, particularly with regard to the ban on net-mesh sizes of 7 inches and greater. These larger mesh sizes were no longer imported or sold in Western Province.

The NFA instituted a new catch-reporting system for the companies that buy most of the barramundi. Records of sales by fishers to the Daru companies since 2003 indicate that the fishery has stabilised on the coast, suggesting that the sustainability objective of the management plan is working. However, the minimum size (36 cm) regulation is not being strictly adhered to, and large numbers of undersize fish are still sold on the open market in Daru.

A successful fish-processing facility was developed in Obo. It employs about 10 local people in the plant as process workers, and supports up to about 100 local fishers delivering barramundi to it.

Barramundi catches at the conclusion of the ACIAR project were over 100 tonnes per year and possibly not sustainable. The implementation of the new management plan was thus vital for this fishery. The latest data from the Obo fishing company indicate that, unlike the situation on the coast, there has been a marked decline in barramundi sold to the processing plant at Obo since about 2001. The reasons for this decline are not clear, but may not be related to overfishing, because research monitoring by OTML does not show a decline in numbers of large females. The decline may be due to a reduction in the numbers of fishers, less fishing activity due to high river levels, changes in the migration patterns of the fish as a result of environmental changes and, finally, the high proportion of people in the Obo region now receiving OTML compensation payments.

An important part of the new management plan was the formation of a Barramundi Management Advisory Committee composed of government, technical, community and industry representatives which, according to regulations, should meet once a year to monitor, review and recommend any changes required to the legislation as the fishery changes. Unfortunately, this committee has met only once, at its inauguration in 2003.

First meeting of the Barramundi Management Advisory committee in 2003.

Impact—the difference the project has made or is expected to make

Community impacts—the beneficiaries of the project

The fishing companies at Daru and Obo have adhered to the new catch regulations and are hence promoting sustainable fishing by their suppliers—the small-scale fishers. These fishers are able to sell their catch directly to the processors and should be able to look forward to the long-term viability of the fishery. Additionally, the provision of employment to at least 100 staff by the four fish-processing plants is significant in an area with few paid employment opportunities.

The development of barramundi aquaculture, subsidised by Ok Tedi, is vital for long-term sustainability of the fishery. The integration of wild fisheries and aquaculture in providing product to the processors should ensure increased employment for fishers and for local people in the processing industry. The aquaculture plan currently being developed is projected to have major positive benefits for food security in Western Province within about 10 years.

The project has affected the many different subsistence fishing communities in two main ways according to their location in relation to fish-processing plants and the market chain.

Fishers in the middle Fly, Fly River delta area, and the coastal region around Daru have continued to benefit from being able to sell their fish to the various fishing companies, which lend them nets and, in some cases, provide a cold chain and fuel subsidised through OTML or OTDF. It is noteworthy that these same fishers are also almost all beneficiaries of compensation payments from OTML.

On the other hand, fishers who are remote from markets have not benefited directly from the project. Nevertheless, if the management plan is ultimately successful and the sustainability of the barramundi assured, this will be of great significance in terms of future food security.

Local communities along the Fly are also beginning to benefit from OTDF-sponsored tourist developments (such as the Suki Lodge on the middle Fly) for wealthy, mostly expatriate, recreational barramundi fishers. The staffing needs of such lodges provide paid employment. There are also payments for services through the provision of boats and crew for recreational fishers.

Factors affecting the size and extent of the impact

Factors that may affect the size and extent of the impact of adoption of the management plan include:

- the future of the Ok Tedi mine, which is scheduled to close in 2013 and is the region's major employer and buyer of fish from the middle Fly. If the mine closure goes ahead, replacement markets will need to be found for the barramundi from the Obo Fishing Company.
- changes to the OTML compensation payments situation. The cash currently paid to people along the Fly River and Western Province coast reduces the numbers of people fishing for their livelihood. Any cessation of payments is likely to increase fishing pressure.
- the export price of barramundi—particularly fish for the Australian market.

Although the results of the project and the reasons for the new regulations were made known to fishing communities, there is no enforcement of the regulations and their adherence depends on continuing community support. Reinforcement is hampered by logistics and lack of infrastructure throughout Western Province, where government has almost no capacity. The current community liaison being undertaken by OTML and OTDF, mostly developed during the project and now being reinforced by the Western Province Sustainable Aquaculture Co., represents the best hope for adoption of the new regulations and the continuing sustainability of the fishery.

The ever-increasing population in the Daru area, caused by migration of people from inland (driven partly by compensation payments from Ok Tedi that are paid out at Daru) is placing greater stress on all natural resources on the coast, and must be viewed as a long-term threat to the viability of a sustainable barramundi fishery. Finally, management of this, or any fishery, is dependent on good catch data, and the current system instituted by NFA is working largely through good liaison between fishing companies and NFA. Without the continued provision of catch data, any changes needed to the management of the fishery in future would be difficult to detect and implement.

In-store drying of grain in China (PHT/1994/037)

Robert Driscoll

Project number	PHT/1994/037
Project name	In-store drying of grain in China
Collaborating institutions	▪ Australia: School of Chemical Engineering and Industrial Chemistry, University of New South Wales (UNSW) ▪ China: Chengdu Grain Storage Research Institute, Stored Grain Research Laboratory (SGRL), Chengdu; Division of Storage and Transportation, State Administration of Grain (SAG), Beijing
Project leaders	Robert Driscoll (UNSW), Guo Daolin (SGRL) and Li FuJun (SAG)
Duration of project	1 January 1997 – 30 June 2001; extension 1 July 2001 – 30 June 2003
Funding:	$1,101,341
Countries involved	China and Australia
Commodities involved	Rice and maize
Related project	PHT/1990/008

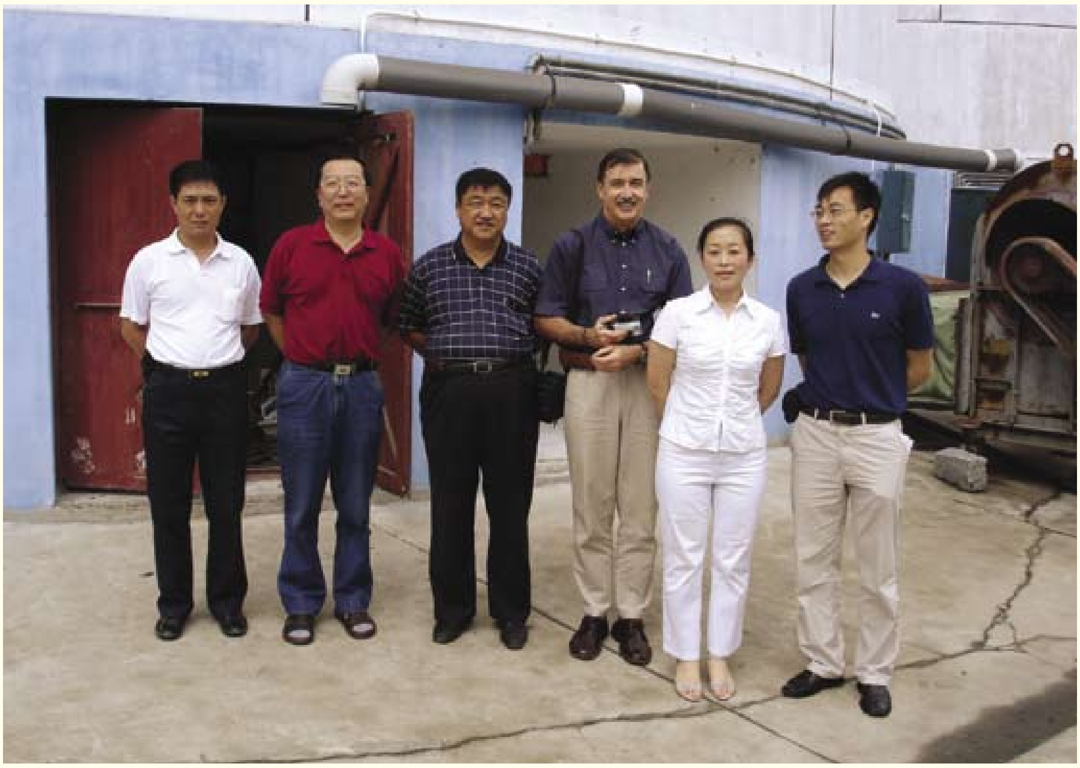
Motivation for the project and what it aimed to achieve

This project was proposed in response to China's concern over grain postharvest losses, and was designed to improve Chinese grain-handling systems through the introduction of in-store drying. This was a developmental project, although there was a strong research component concerning the adaptation of the technology to specific Chinese climatic and postharvest conditions, such as sub-zero storage temperatures. Grain losses in China at the time were about 17–18%, and losses in stores were about 5–8%. There was also significant quality deterioration during storage.

The objective was to apply the known technology of in-store drying, based on previous ACIAR work in South-East Asia. The crops were chosen on the basis of volume: wheat around middle China, rice in the south and maize in the north-east. Wheat was dropped from the scope in early project development, and maize was replaced by rice due to changes in purchase patterns in north-eastern China, with most successful adoption for maize eventuating in the south.

Of all drying options, in-store drying (often called ventilation drying) has the highest thermal efficiency, utilises existing storage equipment, is the cheapest to install and operate, and produces the best-quality grain.

Australian project scientist Dr George Srzednicki confirming the status of an aeration control box after installation at Zhaodong grain storage depot.



Research Group standing outside converted silos at Zhaodong depot: Plant technician, Liu Fangjiu, Zhao Shouzhi, George Srzednicki, Zhong Lixin and Yuan Zuoyun. Note the large aeration fan and ducting behind the group.

What the research project produced

The main project outputs are:

- transfer of technology, through teaching, construction of prototype and finally pilot-plant facilities, and scientific training on assessment of grain quality such as ergosterol determination
- complete pilot-plant demonstrations for maize at Zhaodong depot and for rice at many locations in Heilongjiang and Sichuan, and commercial plant demonstrations over many years at many sites (in Heilongjiang, Sichuan, Jiangsu, Yunnan, Hunan, Hubei and Liaoning provinces)
- documentation of the thermophysical properties of Chinese maize and rice (required for equipment design and dryer simulation)
- GST, a computer-assisted learning system, which has been publicised and is being widely used as a training tool in China. GST was financially supported by ACIAR and AusAID. Also developed was simulation software for sub-zero aeration conditions (prevalent in north-eastern China)
- demonstration of the technology throughout China.

After modification of the concepts to Chinese conditions, demonstrations over several years of full-scale systems in the provinces of Heilongjiang, Sichuan, Jiangsu (especially Zhangjiagang) and Yunnan, for both maize and rice, were used to prove the technology. The data have been publicised through papers in scientific journals, conferences, training workshops and various electronic media.

In addition, the original project has led to several follow-up projects, including:

- Srzednicki, Liu Fang Jiu and Zhong Li Xin: Development of intermediate scale low-cost drying and storage technologies for grain
- Zhao Shou Zhi, Liu Fang Jiu, and Guo: Delivery of in-store dryers to a reclamation farm area (Jiansanjiang)
- Srzednicki and Guo Dao Lin: Development of methods for quality testing of grain in storage
- Liu Fang Jiu and Fu: Village farm development of in-store dryers.

Zhaodong depot manager, Zhong Lixin and Dr Srzednicki at Zhaodong depot in winter, showing the conditions under which maize would be received and processed. The computer design programs were adapted especially to accommodate subzero conditions.

Liu Fangjiu outside Zhaodong converted storage silos, showing the large intake of the aeration fan which feeds the internal vertical aeration piping.

Adoption—how the project outputs are being used

The project has fast-tracked adoption of in-store drying in China, the benefits of which are:

- significant improvement in product (especially a reduction in grain breakage and non-enzymic browning reactions caused by high-temperature dryers)
- reduction in capital and operating costs for dryers; for example, an in-store dryer is six times cheaper than a column dryer of the same capacity and drying costs are less than one-third the cost of sun drying
- space saving and reduced handling, since the dryer is also the store.

At the present stage, adoption appears well advanced for rice, and is gaining acceptance for maize in the south. The technology has not been extended to wheat and other products but should be equally effective if it is.

Adoption for rice has been rapid. Rice is one of the two major crops in the north-east. In the north, upper limits for adoption are expected to be about 40%, where high moisture harvests indicate fast drying will predominate. For southern provinces, only the in-store dryer is necessary. This technology is now completely adopted at the warehouse level (15% of crop). The remaining 85% of the crop in the south is handled at village level where quantities handled are too small for use of the technology developed. However, the Zhongliang Company involved in the project has down-scaled the in-store drying technology with the aim of expanding into this market.

In the north-east there seems to be little awareness outside the scientific community of the economic advantage of drying maize using a column dryer and in-store drying in tandem.

The main reasons for slow adoption for maize appear to be:

- high grain moisture at the time of harvest
- the unexpected increase in private demand, resulting in less maize being stored at the depots of grain bureaus
- the lack of concern about final maize quality (as it is used mainly for animal feed).

Impact—the difference the project has made or is expected to make

One of the largest agricultural dryer manufacturers in China (Zhongliang) now promotes in-store drying as the first option, there are potential large-scale applications in a new rice area called Jiansanjiang, and the technology has advanced rapidly in the south. In areas where the technology has been demonstrated, it is well known and publicised by depot managers and grain bureaus and aggressively discussed, so that the rate of adoption is limited only by the rate of reinvestment. The Zhongliang company has commercialised the technology. It has also modified it to design a series of village-level in-store dryers, with commitments to build 400–900 such units in the short term.

The impact of the project has been strongest in the south, due to the Deng Xiaoping initiative towards land ownership, which has generated a competitive drive towards technology improvement. Here, adoption of aeration technology is close to 100% in depots or stores, but will take time to penetrate to the sun-drying majority (80–90%), even though sun drying has been proven to be more expensive. Since project completion, Chinese scientists have continued in-store research with massive trials each year.

In-store drying is now understood to be the preferred option for grain drying in the eastern half of China.

Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia (PHT/1996/004)

Ivan Kennedy

Project number	PHT/1996/004
Project name	Monitoring mycotoxins and pesticides in grain and food production systems for risk management in Vietnam and Australia
Collaborating institutions	▪ Australia: University of Sydney; CSIRO Plant Industry, Canberra; AWB Research Ltd, Werribee, Victoria ▪ Vietnam: Post Harvest Technology Institute (PHTI), Ho Chi Minh City; University of Agriculture and Forestry (UAF), Ho Chi Minh City; Pasteur Institute, Ho Chi Minh City
Project leaders	▪ Ivan R. Kennedy, University of Sydney ▪ Le Van To, Post Harvest Technology Institute/Southern Institute of Agricultural Engineering and Post Harvest Technology (SIAEP)
Duration of project	1 July 1999 – 30 June 2004
Funding	$1,088,389
Countries involved	Vietnam and Australia
Commodities involved	Maize, wheat, rice, coffee, tea, soybeans and leafy vegetables
Related projects	None

Motivation for the project and what it aimed to achieve

Two local crises recognised in southern Vietnam in the mid-1990s motivated the project. One of these was severe aflatoxicosis in poultry, caused by fungal production of aflatoxin (a mycotoxin) in feeds such as maize meal. This led to poor growth and reduced egg production as a result of liver disease. The second crisis was the widespread contamination of horticultural produce with pesticide residues, directly affecting human health. The project aimed to conduct a baseline survey of these problems in Vietnam and to provide technology transfer allowing adequate monitoring of mycotoxin and pesticide residues in agricultural produce with a view to reducing their incidence.

What the research project produced

Technical outputs in the project by the PHTI included:

- several new rapid diagnostic enzyme-linked immuno-sorbent assay (ELISA) tests for the aflatoxin and ochratoxin A mycotoxins, and for pesticide residues of cyclodienes and DDT. Previously, such tests were available only as imports at prohibitive cost for Vietnamese laboratories. More easily used than analytical methods based on accurate instrumental analysis, the ELISA tests are designed to be used in any laboratory but they cannot be directly used by agricultural producers.

A busy lab session at the ACIAR project's Da Nang workshop in 2004.

Current trainee Ms San Trân Anh surveys a pesticide chromatogram on the SIAEP's ECD gas-liquid chromatograph.

- an improved version of an anti-cholinesterase test known as the RBPR (rapid biological pesticide residue) test aimed at detecting highly toxic organophosphate (OP) pesticide residues in horticultural produce such as leafy vegetables and fruit
- validated procedures for preparation of immunoaffinity columns for aflatoxin (IACs). IAC columns prepared by the PHTI have had an important role in raising the analytical capability of users such as other analytical centres in Vietnam.

These technical outputs were independently produced by the Vietnamese participants working in Vietnam; during the same period they were trained in all aspects of the technology in Australia.

Capacity development occurred in the following areas:

- Baseline surveys were conducted for mycotoxins and pesticide contamination in a range of produce including maize, coffee, vegetables and fruit in the Ho Chi Minh City area. Eight short documents containing these data were published in Vietnamese.
- Six Vietnamese scientists were trained professionally in Australia in ELISA technology so they could independently prepare test kits for mycotoxins and pesticides. They also developed skills for demonstrating the use of these ELISA kits. Three years after the conclusion of the project, three technicians continue to produce test kits and IACs to satisfy the local demand.

A set of SIAEP's immuno-affinity columns (IACs) for aflatoxin measurement.

- A specialised laboratory for effective preparation of ELISA kits and to service ongoing kit and IAC production was set up at the PHTI in Ho Chi Minh City. An animal house capable of maintaining 12 rabbits was commissioned during the project extension at another site. An analytical laboratory containing equipment for high-performance liquid chromatography (HPLC) for mycotoxin analysis and gas chromatography (GC) for pesticide analysis was also established.

These physical analytical facilities all remain in operation 3 years after the project concluded, housed in new, purpose-built space provided by additional floors in the SIAEP–PCC building completed in 2006. Additional instruments such as an atomic absorption spectrometer have been added to this stock.

There was also an increase in organisational capacity to undertake research efficiently and effectively and attract research funding, and in the organisational linkages formed.

Linkages were developed with other universities and institutes in Vietnam.

Adoption—how the project outputs are being used

Adoption of outputs relates to the provision of analytical products such as ELISA kits and IAC kits needed to monitor mycotoxins and pesticides, as well as the capacity to extend knowledge about this technology and its use to educational institutions and to other industry users.

In the 3 years since the project concluded, many training workshops and courses in ELISA and IAC technology using Vietnamese-produced kits and products have been conducted, demonstrating the ongoing effectiveness of the capacity developed. Most recently, instruction was provided at the SIAEP in the ASEAN Training Course for Quality in Vegetables and Fruits in December 2007.

IAC columns have been employed by several analytical laboratories in Ho Chi Minh City for clean-up of samples for aflatoxin analysis using thin-layer chromatography and HPLC. Ho Chi Minh City's Plant Protection Department (PPD) applied the project's RBPR pesticide kit to survey organophosphates in fruit and vegetables in the period 2001–2006, and a campaign was also conducted in Vung Tau province in 2004–2005 leading to a reduction in reported chemical residues. More than 400 aflatoxin IACs have been provided to analytical services as final users since 2004, but the demand exceeds the capacity of the SIAEP (renamed from PHTI) to produce these items.

The SIAEP ELISA/IAC team in 2008: From left to right, Ms Tran Thi Kim Oanh, Ms San Trân Anh, Mr Tran Thanh Binh and group leader Mrs Nguyen Thu Trang.

Ideally, a commercial partner would have been found to take over the ongoing production and the sales and promotion of such kits, relieving the SIAEP of this responsibility. In this case the SIAEP would have continued to provide technical backup to the commercial partner but each could concentrate on its area of expertise. This possibility was promoted as part of the two-year extension phase of the project but it did not eventuate.

Impact—the difference the project has or is expected to make

Adoption of the project technology by final users such as grain mills, or in monitoring agencies, has resulted in a significant impact on the quality of produce that is reflected in sampling programs, particularly in southern Vietnam. The benefits clearly affect the whole community, by allowing risk management for such contaminants. Farmers supplying the produce benefit if they receive suitable feedback (as they should from grain mills) by being able to improve their practices, such as arranging better storage of products such as maize or nuts under drier conditions. Producers using feeds that may be contaminated with toxins benefit by better growth rates and better quality of their animal produce or in aquaculture, lessening the risk of costly rejection by the export market that is sometimes attended by financial penalties. Finally, the consumers of agricultural produce will clearly benefit by the reduced risk to their health when supplied with better-quality produce.

An assessment of the agricultural produce at risk indicates that about $US5 billion of Vietnam's annual produce, much of which is for export, can be considered at risk of contamination. The SIAEP is well placed to contribute to improving the quality of about $US100 million of this produce. Considered as an insurance premium, the expenditure of about $US1 million to help generate analytical products and capacity to protect future products and implement more effective public policy is modest.

Environmental benefits are also a feature of adoption of this pesticide-screening technology.

The UAF and the Hanoi College of Science, Vietnam National University, conducted field surveys of pesticide residues in the north and south of Vietnam. ACIAR funded the publication of a monograph on risk management edited by AusAID project members from the two Vietnamese universities. A Vietnamese version, with an additional section on ELISA technology, was published in 2005 using ACIAR funds. This was distributed widely to universities and technical colleges. Project experience was also recorded in a chapter in a book published by the American Chemical Society and Oxford University Press (Kennedy et al. 2007[1]).

SIAEP suggests that the impact of the project would be further enhanced if resources could be found to compile a book in Vietnamese, with a title along the lines 'Immunological analysis methods for food safety—theory and practice', documenting the capacity it has developed in this area. This would provide a resource that would help popularise and maintain this technology in Vietnam, emphasising the role of ongoing monitoring by rapid tests for contaminants as a normal part of supply-chain management.

1 Kennedy I.R., Solomon K., Gee S., Crosnan A. and Shuo Wang (eds) 2007. Rational environmental management of agrochemicals: risk assessment, monitoring, and remedial action. American Chemical Society Symposium Series, No. 966. Oxford University Press: New York

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ACIAR
Part of Australia's development assistance program

Australian Centre for International Agricultural Research

GPO Box 1571, Canberra ACT 2601

Phone: (Int +61 2) 6217 0500

Email: aciar@aciar.gov.au