# ADOPTION OF ACIAR PROJECT OUTPUTS

## STUDIES OF PROJECTS COMPLETED IN

# 2007–08

Australian Government

Australian Centre for International Agricultural Research

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Editors: Amir Jilani, David Pearce and Debbie Templeton

**2013**

ACIAR
Research that works for developing countries and Australia

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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 Adoption Studies**

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 commissions project leaders and participants to revisit projects 3–4 years after completion, and report back to ACIAR on the medium-term outcomes of the work. This series reports the results of these studies.

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# Foreword

As a gauge of the success of ACIAR's investments in research, we place great store on establishing levels of adoption of the results emerging from projects. The adoption studies recorded here are a sample from nine projects that concluded in 2007–08. They took place in nine countries and covered a broad range of topics.

The reviewers have based their assessments around three parameters: 1. adoption of new technologies or practical approaches dealing with particular problems or issues; 2. uptake of new scientific knowledge or basic understanding (pure or basic science) of the phenomena or social institutions that affect agriculture; 3. acquisition of knowledge, models and frameworks for policymakers or broad-level decision-makers.

The results of the nine studies indicate medium to high levels of adoption of the project results. Not surprisingly, new technologies or practical approaches—targeted at the farm level and more broadly at research project managers and breeders—were the major outputs for most of the projects. In addition, the projects involved extensive capacity building within partner countries and institutions. This affirms the value of our long-established practice of providing formal university-based training as well as a variety of on-the-job training opportunities.

A discussion of the major factors that affect adoption provides some useful lessons. Relatively high levels of adoption appear to have been driven by strong economic incentives, such as improved incomes, higher yields and greater crop choice. Where levels of adoption were low, the reviewers identified factors such as difficulty in accessing the target audience, high staff turnover resulting in limited adoption upon project completion, and cultural barriers prolonging the time to adoption.

Sustaining the work after the conclusion of the project is equally important. The reviewers found that, in most cases, the research capacity and research infrastructure continued to be used. There were, however, instances where trained staff moved to take positions in other organisations or departments and left no technical expertise behind. This is a reminder that we need to maintain relationships that ensure ongoing training and encouragement if we wish to see adoption truly embedded in our partner institutions.

**Nick Austin**
Chief Executive Officer, ACIAR

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# Overview

**Amir Jilani, David Pearce and Debbie Templeton**

## Introduction

This report summarises the adoption results for nine Australian Centre for International Agricultural Research (ACIAR) projects completed in 2007–08. The countries and research areas covered in these nine projects are diverse. The projects presented here cover:

- nine individual partner countries (Cambodia, China, Fiji (two projects), Indonesia, Myanmar, Papua New Guinea, the Philippines, Samoa and Vietnam)
- three livestock health and related projects
- one horticulture project addressing the development of the industry
- four crop-related projects (sugarcane, taro, land suitability for crop diversification, and weed management in cropping)
- one soil project identifying site-specific soil constraints.

The outputs from these projects show a very broad pattern of results. Most projects developed new technologies or practical approaches designed for use by farmers and crop growers, staff and managers, or breeders.

Many of the projects also developed new scientific knowledge that will help future research and management decisions. This knowledge ranged from enhanced understanding of soil properties and land capability, to the confirmation of the existence of herbicide resistance in rice-growing regions in the Philippines.

Four of the projects also developed knowledge for policy and policymakers, ranging from information about the health of livestock in targeted countries and provinces, to new knowledge of land capability and relevant implications for policy. One project resulted in outputs that assisted farmers to meet a legislative requirement to produce an environmental risk assessment in regulated catchments in Queensland, Australia.

All of the projects involved extensive capacity building within partner countries and institutions, ranging from formal university-based training to a variety of on-the-job training approaches. Many projects also involved the establishment of basic research infrastructure that continues to be used in many cases.

The nine adoption studies indicate medium to high levels of adoption of the project results, although adoption by final users was limited in some cases. In all cases, the adoption results nevertheless provide some useful ongoing lessons and observations.

## What was discovered — project outputs

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

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

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

**New technologies or practical approaches** were the major outputs for most of the projects. These were targeted at both the farm level and, more broadly, at research project managers and breeders.

New technologies at the farm level included:

- development and production of vaccines to control vvIBDV, a poultry disease
- a pesticide recommendation package for producing undamaged taro corms
- methodologies for soil survey and land capability assessment
- a manual to identify site-specific soil constraints
- soil and fertiliser management strategies to increase yields and/or financial returns
- locally adapted recommendations for weed management
- genetic populations derived from wild germplasm and selected clones, for use in breeding programs.

**New scientific knowledge** was an important output of most of the projects. The subject matter of this was highly variable, ranging from better understanding of land capability in Cambodia and new awareness of basic soil properties and soil nutrients in Vietnam, to novel information regarding the appropriate use of insecticides for beetle management in Papua New Guinea (PNG) and Fiji.

Six projects also developed **knowledge or models relevant to policymakers**. Again, this knowledge was diverse and included insights into the health of livestock and the potential for public health risks from zoonotic diseases (as in the case of the livestock health project in the South Pacific) as well as the uptake of management principles to assist in environmental risk assessments (Soil Constraints and Management Package (SCAMP) principles are used to help the preparation of environmental risk management plans in Australia). Knowledge to support policymaking also included increased understanding of the characteristics of village chicken production systems (and their weaknesses) in Myanmar.

### Table 1. Summary of project outputs

| Project | New technologies or practical approaches | Scientific knowledge | Knowledge or models for policy and policymakers |
|---|---|---|---|
| 1. Development of a vaccine for the control of Gumboro in village and small poultry holdings in Indonesia | Four 'master seeds' developed for production of vaccines to control vvIBDV (an economically important poultry disease)<br><br>New diagnostic tests for vvIBDV | Identification of the predominance of vvIBDV strains in poultry in Indonesia<br><br>Scientific expertise on vvIBDV, which is exotic to Australia | Scientific data to enable the Australian poultry industry to establish freedom from vvIBDV and support Australia's current status in international trade as vvIBDV-free |
| 2. The identification of the constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific | | Unique information on the epidemiology of leptospirosis in livestock and domestic animals and the likely impact on animal and human health | Information on the incidence of *Trichinella*, a parasite threatening public health, in Fiji, Kiribati, and Papua New Guinea (PNG) |
| 3. Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar | Procedures (and associated extension methodologies) to improve village management of chicks during their first 6 weeks<br><br>Molecular polymerase chain reaction diagnosis for detection of Newcastle disease introduced to the Livestock Breeding and Veterinary Department | Demonstrated that the use of ACIAR-developed I-2 Newcastle disease vaccine results in reduced mortality of chickens in Myanmar<br><br>First genetic characterisation of Newcastle disease viruses circulating in Myanmar | First detailed description of the village chicken production system in Myanmar and the constraints to this system |

continued …

**Table 1. (continued)**

| Project | New technologies or practical approaches | Scientific knowledge | Knowledge or models for policy and policymakers |
|---|---|---|---|
| 4. Use and improvement of sugarcane germplasm | Genetic populations derived from wild germplasm in China | New knowledge and data about genetic diversity in wild germplasm<br>New knowledge about the use of DNA markers in sugarcane introgression breeding<br>New knowledge about differences between Australia and China in genotype environment interactions | |
| 5. Taro beetle management in PNG and Fiji | Pesticide recommendation package developed for farmers to enable them to produce undamaged taro corms | New information on appropriate insecticides for the control of the beetles in the field<br>Findings on the impact of using biological control organisms, *Metarhizium anisopliae* and *Oryctes* virus | |
| 6. Horticulture industry development for market-remote communities in Samoa and Australia | Range of professional information products, field guides and information sheets produced for advisory staff and farmers<br>Production of video material for training and promotion of new technologies for crop production | Awareness of social research methods and their application for information needs analysis | Development of a model for information delivery by the Ministry of Agriculture and Fisheries in Samoa |
| 7. Assessing land suitability for crop diversification in Cambodia and Australia | The National Soil Profile Database<br>Methods for soil survey, land capability assessment and laboratory analyses<br>Database to produce reports, papers, maps, assessments and manuals | Enhanced knowledge of different soil types and crop suitability for upland crop production and improved understanding of land capability | Policy recommendations on land capability and the suitability of cropping options |

continued …

**Table 1. (continued)**

| Project | New technologies or practical approaches | Scientific knowledge | Knowledge or models for policy and policymakers |
|---|---|---|---|
| 8. Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia | Soil Constraints and Management Package (SCAMP) manual (in English and Vietnamese)<br>SCAMP-based soil and fertiliser management strategies to mitigate constraints and increase yields and/or financial returns | New awareness and knowledge of basic soil properties and sustainable soil management practices | In Australia, SCAMP principles used not only to prepare soil-specific nutrient management plans but also to assist in providing an environmental risk assessment |
| 9. Herbicide use strategies and weed management options in Filipino and Australian cropping | Locally adapted and understood Integrated Weed Management practices. | New awareness of the existence and risk of herbicide resistance in many rice-growing regions | |

## Capacity development

Most of the projects presented here had explicit objectives to improve the capacity for research and development in partner countries, and all of the projects had substantial capacity-building outcomes. Table 2 summarises the capacity developed and used in the projects covered in this report.

Capacity development included training in basic experimental and research skills, through both formal training and less-formal on-the-job training. Many of the projects involved training to obtain higher academic qualifications, including doctorates.

A number of the projects included the enhancement of research infrastructure, varying from basic laboratory equipment and reagents provided as part of the project, to the development of a quarantine glasshouse and associated protocols as a result of project support.

In most cases, the research capacity and research infrastructure continue to be used. In a few cases, researchers who were originally junior during the course of the project now hold senior positions within relevant organisations. In other cases, trained staff have moved to take positions in other organisations or departments, often leaving no technical expertise behind. In some cases, capacity has not continued to be used after project completion due to limited opportunities to apply specific technical skills outside of the project.

### Table 2. Research capacity built by the projects

| Project | Partner-country/ies research capacity built | Research infrastructure | Capacity used |
|---|---|---|---|
| 1. Development of a vaccine for the control of Gumboro in village and small poultry holdings in Indonesia | Laboratory manual for production and quality control of master seeds<br>Enhanced capacity of partner-country research institute and its scientists in IBDV diagnosis, vaccine development and evaluation | Reagents for the differentiation of vvIBDV | Expertise and knowledge of those involved in developing IBDV vaccine in Indonesia have been used to provide training and advice in the further development of vaccines<br>Reagents have been used in a diagnostic test |
| 2. The identification of constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific | Postgraduate training of researchers to higher degree, including PhD, level<br>Project training and skills and knowledge development of laboratory staff at the National Veterinary Laboratory (NVL) | Infrastructure, equipment and reagents provided during the course of the project | Infrastructure provided to the National Agriculture and Quarantine Inspection Authority has become essential for the continuing functions of the NVL<br>Equipment continues to be used, improving efficiency<br>Ongoing employment of skills and knowledge by laboratory staff and researchers |
| 3. Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar | Considerable training of Livestock Breeding and Veterinary Department (LBVD) staff through both formal courses and through working alongside Australian researchers, including: capacity building in epidemiology and disease surveillance; molecular methods for diagnosis; vaccine production and quality control; and extension methodologies | Diagnostic equipment (PCR machine, centrifuges etc.) | Capacity in molecular diagnostics now well embedded in LBVD<br>Equipment continues to be used and has been upgraded<br>Epidemiology section of LBVD has been expanded |

continued ...

**Table 2. (continued)**

| Project | Partner-country/ies research capacity built | Research infrastructure | Capacity used |
|---|---|---|---|
| 4. Use and improvement of sugarcane germplasm | Development of capacity to identify ratoon-stunting disease (RSD) in sugarcane and to develop clean-seed schemes; to undertake DNA marker analysis; and in applying quarantine procedures for the international exchange of sugarcane germplasm<br><br>New knowledge among breeders, including methods for better data analysis and family selection | Development of a quarantine glasshouse and associated protocols as a result of cooperation and support provided by the project | Capacity continues to be used across a range of areas—some skills, such as use of DNA markers, are being employed routinely in breeding programs, while the use of others is increasing rapidly<br><br>There is considerable use of all capacity outputs by breeding staff (next users) as well as farmers (final users) |
| 5. Taro beetle management in PNG and Fiji | A range of training workshops and hands-on training in pesticide application and safety, and laboratory and field procedures<br><br>Enhanced capacity to undertake participatory approaches to technology transfer to farmers | | Recommendations and training provided through the project have been adopted by taro growers and the taro industry as a whole |
| 6. Horticulture industry development for market-remote communities in Samoa and Australia | Staff completing PhD studies as a result of their involvement in the project have taken up, or are expected to take up, new senior positions<br><br>Enhanced capacity of information officers within the Ministry of Agriculture and Fisheries (MAF) Samoa to develop publications and new information products | | The information team continues to operate effectively within its capacity, and influences other information units within MAF |

continued …

**Table 2. (continued)**

| Project | Partner-country/ies research capacity built | Research infrastructure | Capacity used |
|---|---|---|---|
| 7. Assessing land suitability for crop diversification in Cambodia and Australia | Through extensive training, staff skills developed in research experiments, soil surveying, and production of the soil and landscape models<br><br>Laboratory capacity developed for analyses of soil, plant and water samples | Equipment for soil collection and soil water measurement was provided. | Staff in the Soil and Water Sciences Division continue to use skills gained and are in positions to extend the knowledge of the project<br><br>The division also continues to participate in soil survey tasks |
| 8. Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia | Soil Constraints and Management Package (SCAMP) manual used to train provincial extensionists, champion farmers and non-government organisation project staff<br><br>Training course provided in the application of MapInfo and geographic information system technology to produce maps of soil properties<br><br>Institute of Agricultural Sciences (IAS) of Southern Vietnam scientist responsible for day-to-day management of the project selected to complete a PhD in soil chemistry | Provision of equipment to the IAS laboratory for the field determination of soil properties<br><br>Formalised laboratory quality assurance (QA) and quality control (QC) procedures introduced. | SCAMP training continues to be provided to smallholders<br><br>Maps of point data for a range of soil properties were produced by trained IAS staff even though opportunities for the continuous application of skills developed remain limited<br><br>The IAS lab has an ongoing commitment to QA/QC and has consistently gained certification for several analyses |
| 9. Herbicide use strategies and weed management options in Filipino and Australian cropping | Development of herbicide resistance and integrated weed management capacity<br><br>Development of a strong weed research team through international training | | PhilRice team developed into the strongest weed research team in the region, with two researchers gaining PhDs<br><br>Capacity developed continues to encourage ongoing expertise, capability and protocols for herbicide-resistance research |

## Uptake of the research and development outputs—progress along adoption pathways

Table 3 summarises the adoption outcomes for the projects covered in this report.

Most of the projects covered here had a number of different objectives and outputs. Summarising the often complex adoption outcomes for a range of projects is inevitably a difficult task and involves an element of judgment. For the summary presented in Table 3, as in previous adoption reports, a four-level classification scheme is used.

In this classification scheme, the lowest level of adoption is *O*, or no uptake of the results by either initial or final users of the outputs of the project. As Table 3 indicates, only one project had no adoption of *some* of the project outputs (although there was medium adoption of other project outputs).

The next level of adoption is *N*, the circumstance where there has been some uptake by initial users but no uptake by final users of the research. Seven projects had some outputs falling into this category (again, in each of these cases, other components had higher adoption).

The next level of adoption is *Nf*, the circumstance where there has been uptake by initial users and some uptake by final users. Seven projects had outputs falling into this category.

The highest level of adoption, *NF* (use by initial and final users), was achieved to some degree in at least some of the project components in four of the projects reported here.

### Table 3. Current levels of adoption of key project outputs

| Project | New technology/practical approach | Scientific knowledge | Knowledge, models for policy |
|---|---|---|---|
| 1. Development of a vaccine for the control of Gumboro in village and small poultry holdings in Indonesia | *N* — As vaccines have just been produced in Indonesia, there are no measurable changes or improvements for poultry farmers (final users). A veterinary vaccine manufacturer has commenced advertising and distribution of the four vaccines but use of these vaccines is unknown. | *N* — Scientific expertise in the area of IBD has benefited the local poultry industry in Australia and enabled it to ascertain its status as vvIBDV-free. | *N* — Knowledge gathered provides scientific justification for Australia to ensure it maintains its status as vvIBDV free. |

continued …

Table 3. (continued)

| Project | New technology/practical approach | Scientific knowledge | Knowledge, models for policy |
|---|---|---|---|
| 2. The identification of constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific | | *Nf* — use of information by major commercial cattle and crocodile producers, including Mainland Holdings, to certify exports are free from the parasite<br>*N* — use of information by the project leader to provide technical assistance to the secondary users in Fiji (Ministry of Health) | *Nf* — use of information by secondary users such as the Ministry of Health to develop a national strategy for the control of leptospirosis |
| 3. Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar | *Nf* — procedures to improve village management of young chicks<br>*Nf* — molecular diagnostic methodologies<br>*N* — extension methodologies | *NF* — adoption of vaccine in village chickens | *Nf* — knowledge used by government agencies in designing surveillance and control programs |
| 4. Use and improvement of sugarcane germplasm | *NF*—Most of the technical outputs (e.g. hybrid and backcross clones) have been taken up by sugarcane breeders but have yet to give rise to release of commercial varieties, although final users' adoption of clean seed is beginning to have a large economic impact in farming communities. | *N*— Most of the knowledge outputs saw some use by sugarcane breeders (with the exception of new knowledge about using DNA markers). | |
| 5. Taro beetle management in PNG and Fiji | *NF* — The taro beetle management recommendations have led to the communities in the industry becoming more enthusiastically involved in taro production, as evidenced by an increase in the number of taro fields and plantations. | *NF* — Taro growers, including a women's group in East New Britain, and the taro industry, are using the knowledge gained from the project. | |

continued …

Table 3. (continued)

| Project | New technology/practical approach | Scientific knowledge | Knowledge, models for policy |
|---|---|---|---|
| 6. Horticulture industry development for market-remote communities in Samoa and Australia | *Nf* — Products and information generated through the project have been adopted by Samoan Ministry of Agriculture and Fisheries (MAF) staff. There is limited information on the extent adoption by final users. | *N* — A Samoan project officer employed by the project became confident in the use of rapid rural appraisal, semi-structured interviewing, surveys and the use of focus groups. He attributes improved relationships with growers to the new techniques provided by the project. Staff turnover has limited wider adoption. | *Nf* – MAF has recognised the importance of information products and the strong role a dedicated information unit can play in industry development strategy. |
| 7. Assessing land suitability for crop diversification in Cambodia and Australia | *N* — The national soil database is in some use by initial users, primarily the Cambodian Agricultural Research and Development Institute (CARDI) *N* to *Nf* — The methodology for soil survey and land capability assessment has been adopted by initial users and incorporated in the database. | *Nf* — There has been uptake in knowledge of soil types by all levels of users, including staff in CARDI, rural staff in provincial departments of Agriculture, Forestry and Fisheries as well as district farmers, but findings have yet to be adopted in surrounding districts. | *N* — The methodologies, outputs and recommendations developed by the project have been identified by government strategy documents but may not have been specifically used. |
| 8. Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia | *NF* — The Soil Constraints and Management Package has been applied by extension workers (initial users) and smallholders (final users) in Binh Thuan province to identify soil constraints. The adoption outcome in Gia Lai province was rated *N*, however. | *N* to *Nf* — Adoption was variable. The major factor hampering adoption by the initial users (extension workers and non-government organisation managers) was simply reaching these target audiences. This, in turn, limited adoption by final users. | *Nf* to *NF* — Site-specific soil management has been adopted by sugarcane growers in Queensland through voluntary training and recently as a legislative requirement under the *Reef Protection Act*. |

continued …

**Table 3. (continued)**

| Project | New technology/practical approach | Scientific knowledge | Knowledge, models for policy |
|---|---|---|---|
| 9. Herbicide use strategies and weed management options in Filipino and Australian cropping | *NF* — Integrated water management components have been adopted by rice growers (final users). | *N* to *Nf* — Herbicide resistance and weedy rice information has influenced research and extension but not yet farmer behaviour significantly. | |

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

There is always a wide variety of factors underlying particular adoption outcomes. In a broad sense, a number of common factors emerge related to knowledge, incentives and barriers. These factors can be summarised as follows:

- Knowledge
  - do the final or ultimate users *know* about the project outputs?
  - is there *continuity of staff* in organisations associated with adoption (leading to the ongoing transfer of knowledge)?
  - are the outputs *complex* to absorb relative to the capacity of the users (do users have a sufficient knowledge base to support adoption)?
- Incentives
  - do users have sufficient *incentives* to adopt the outputs?
  - does adoption of the outputs increase *risk* or *uncertainty* for the users (thus reducing incentives to adopt)?
  - is adoption either *compulsory* or indirectly *prohibited* (an extreme form of incentive or barrier)?
- Barriers
  - do potential users face *capital* or *infrastructure constraints*, limiting their ability to fund the adoption of the outputs?
  - do potential users of the outputs face *cultural* or *social* constraints to adoption?

Table 4 summarises some of the major factors affecting adoption for the projects reported here.

Relatively high levels of adoption appear to have been driven by either strong economic incentives such as improved incomes, higher yields and greater crop choice, or the effects of a mix of project outputs, such as certification of parasite-free meat in the case of the livestock health project in the South Pacific, that allowed economic incentives to emerge.

Relatively low levels of adoption resulted from different factors, including difficulties in accessing the target audience, high staff turnover resulting in limited adoption upon project completion, as well as cultural barriers extending the time to adoption. In some cases, adoption outside the targeted regions or districts was absent, meaning that imitation could not always be relied upon.

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

| Factor | | Key findings |
|---|---|---|
| **Knowledge** | *Do potential users know about the outputs?* | In the vaccine development project in Indonesia, it has yet to be determined whether poultry farmers know about vaccines. A possible explanation could be that promotion of the vaccines has only recently been undertaken, and the first batches produced were considered to be test batches.<br><br>In the livestock health project in the South Pacific, the major output was information on the prevalence of diseases in livestock, particularly that applicable to smallholders. Key project outputs were used by major commercial cattle and crocodile producers in Papua New Guinea (PNG) and by the PNG Ministry of Health.<br><br>In the sugarcane project in China, project outputs have not been adopted by farmers and their communities due to the long time needed to develop sugarcane varieties.<br><br>In the taro beetle management project in PNG and Fiji, major outputs have been adopted by end users (taro growers) with considerable enthusiasm.<br><br>In the soil and land capability project in Cambodia and Australia, there has been an uptake of knowledge of soil types by all levels of users, while the use of the national soil database by potential users has been limited, partly due to the database being a stand-alone item with no internet accessibility.<br><br>In the management of upland soils project in Vietnam and Australia, adoption by initial users (extensionists and non-government organisation agricultural development project managers) was limited due to difficulties in reaching this audience. The smallholders (final users) are reached primarily because they comprise the network clients of initial users. Limited outreach to initial users and lack of soil management knowledge among them were thus identified as major constraints to more-effective engagement with final users.<br><br>In the herbicide and weed management project in Filipino and Australian cropping systems, adoption of integrated water management practices by final users (farmers) in the Philippines has increased yields and reduced herbicide use. Adoption by Filipino farmers in districts beyond the project activities has been relatively lower. |

continued …

**Table 4. (continued)**

| Factor | | Key findings |
|---|---|---|
| | *Is there continuity of staff in organisations associated with adoption?* | In the livestock health project in the South Pacific, a major impediment to the adoption of research outputs in the Pacific region was the high turnover of staff in most Pacific island countries.<br><br>In the case of soil and land capability in Cambodia and Australia, a staff member was moved to another department, leaving no residual expertise of the National Soils Database in the Department of Agriculture and Land Management.<br><br>In the case of herbicide use strategies and weed management in the Philippines and Australia, while the original in-country project leader left to work at the International Rice Research Institute soon after the end of the project, there was sufficient continuity of other staff that this did not detract from the strength and capacity of the research team.<br><br>In the horticulture industry development project, training workshops on user-centred information production and on social research methods were delivered as part of the project. While the skills to deliver these courses were also developed, staff turnover has limited the application of these workshops beyond the project. |
| | *Are outputs complex in comparison with the capability of the users?* | This did not appear as a major issue in the projects covered in this report. |
| **Incentives** | *Are there sufficient incentives to adopt the outputs?* | In the case of vaccine development in Indonesia, adoption of infectious bursal disease virus (IBDV) vaccines by poultry farmers would be beneficial as IBD is a disease endemic in all provinces and impacts significantly on the health and productivity of many poultry farms. The benefits of adopting locally produced vaccines would stem from improved disease control due to the use of local, rather than imported, IBDV strains for vaccine production.<br><br>In the case of livestock health in the South Pacific, Mainland Holdings is able to certify that their exports of crocodile meat are free from the parasite.<br><br>In the case of the taro beetle management project in PNG and Fiji, beetle populations threatened the life of the taro crop. The new technology and findings promise to enable management and control the adverse impact of taro beetles.<br><br>In the case of soil and land capability in Cambodia, farmers acquired information and gained knowledge about the soil types capable of growing various field crops. The economic incentives driving this project output included improved incomes and increased crop choice.<br><br>In the case of sustainable soil management in Vietnam and Australia, results from the core demonstration field experiments reveal that smallholder adoption of a site-specific approach to soil management will result in financial as well as sustainability benefits. |

continued …

## Table 4. (continued)

| Factor | | Key findings |
|---|---|---|
| | | In the case of herbicide-use strategies and weed management in Filipino and Australian cropping, implementation of integrated water management practices in the trial fields led to reduced weed weights, increased yields, higher profits and fewer herbicide applications. Other changes may include growing new crop varieties and improved seed quality. |
| | *Does adoption increase risk or uncertainty?* | This did not appear as a major issue in the projects covered in this report. |
| | *Is adoption compulsory or effectively prohibited?* | In the sustainable management of upland soils in Vietnam and Australia project, adoption of site-specific soil management in Australia was made a legislative requirement under the *Reef Protection Act* in regulated catchments in Queensland, where canegrowers would be required to provide environmental risk management plans to the state government. |
| **Barriers** | *Do potential users face capital or infrastructure constraints?* | In the Newcastle disease project in Myanmar, one factor limiting the adoption of improved chick management procedures was the inability to purchase chick starter feed in small amounts (it sold only in 50 kg bags). |
| | *Are there cultural or social barriers to adoption?* | In the case of the horticulture industry development project in Samoa and Australia, the study found that, where new tools were not aligned with the traditional cultural practices of Samoa, adoption was slow and therefore required more-intensive and ongoing support to effect lasting change.<br><br>In the case of sustainable soil management in Vietnam and Australia, there had previously been no cultural experience within the ethnic minorities of permanent agriculture or understanding of the need for nutrient management of soils. The project helped to bring together female extensionists and farmers for training courses and field experiments—indicating the importance of women in the social structure of rural Vietnam. |

## Lessons

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

### The need for more representative data

In the livestock health project in the South Pacific, the study noted that any research designed to understand the risks related to zoonotic diseases must include parallel activities in human and animal populations to ensure that data are available from all potential host species. This was achieved in Fiji during the project but only as a result of the close collaboration between the Secretariat of the Pacific Community and the Fiji Ministry of Health.

### Careful consideration of intended technical and capacity outputs

In the case of the sugarcane project in China, much time was spent on the development of technology and capacity associated with the use of DNA markers. In retrospect, the time spent was not particularly productive and the technology that was used is now redundant. The study notes the importance of first ensuring simple and basic ways of improving industry profitability, such as the use of clean seed and ensuring optimal nutrition, rather than simply funding risky, 'cutting edge' research.

### The importance of ongoing research and engagement

In the project on taro beetle management in PNG and Fiji, the adoption study noted the need to explore alternative methods for taro beetle control. Although insecticides proved to be effective and this has renewed confidence among taro growers, their use may not be sustainable. Chemicals are expensive, and increased usage may even cause environmental problems. Thus, even if project outputs are successfully adopted, there may be opportunities for continuous improvement through ongoing research and engagement.

### Coordination of related projects

In the soil and land capability project in Cambodia and Australia, there was limited coordination between related projects. This meant that three ACIAR projects targeting field crops and crop diversification were operating in different districts and therefore found no continuity of the themes of land capability, farming systems and markets in any one district for any commodity. The study suggests a more integrated approach may have been suitable for the purposes of delivering outputs to other districts as well.

Closely linked to this is the need for caution when relying on imitation by neighbouring farms, districts and regions. This was noted in the herbicide and weed management project in the Philippines where extensive diffusion of integrated weed management based on imitation by neighbours could not always be relied upon.

## Collaboration and partnerships

In the case of sustainable soil management in Vietnam and Australia, collaboration with non-government organisations (NGOs) such as World Vision proved to be an extremely efficient way of achieving appropriate dissemination of awareness and knowledge to the end users. Since NGOs often have effective grassroots communication, the study notes the importance of strengthening collaboration between ACIAR research projects and NGOs and setting this as a high priority to enable ACIAR to maximise project impacts.

Similarly, in the herbicide and weed management project in Filipino and Australian cropping, engagement with in-country research organisations showed the potential for greater research outcomes through collaboration with international expertise as well national extension networks, skills and programs. The benefits of having an influential in-country project leader were also highlighted within this project, providing the potential to reach a larger audience.

## Communication and local language consideration

In the horticulture industry development project in Samoa and Australia, the adoption study notes the importance of writing in the local language and engaging with research and advisory staff for the successful adoption and uptake of project outputs.

Similarly, in the upland soils project in Vietnam and Australian, a key project output, the SCAMP manual, was produced and then translated into Vietnamese to allow local trained extensionists and farmers to apply a site-specific approach to soil and soil fertility management.

## Time frames for adoption

The sugarcane project in China illustrated the long time frames associated with the adoption of certain project outputs. The outputs from the sugarcane project benefited only the next users and had not yet been adopted by the final users (farmers and their communities). This was primarily due to the long time needed to develop sugarcane varities. It may therefore often be too early for end user adoption and a careful consideration of the time frame remains important.

In the vaccine development project in Indonesia, the vaccines developed were adopted by the next user, vaccine manufacturers. However, the study notes that there remain commercial circumstances and problems associated with bringing numerous poultry vaccines into the market in a very short time and these are difficult to foresee or influence. Hence, it may require some time before the vaccines penetrate the market, and the degree of adoption by poultry farmers is difficult to accurately estimate.

## Recognition of external constraints

The impact that a project has can often be outside the control of the project and may require an understanding of the external constraints. In the horticulture industry development project, lack of information (a problem that the project aimed to overcome) was not the major limitation to horticulture development in Samoa. Other factors such as market access and seed availability were noted to be more limiting than information availability by itself. Such issues are therefore often outside the scope or control of the project and may limit the magnitude of the impact, irrespective of the level of adoption of key project outputs.

## Making the research directions responsive to partner needs

In the Newcastle disease project in Myanmar, flexibility in the ultimate direction of research and responsiveness to the needs of partners led to a new area of development (molecular diagnostic assays) not previously part of the project plan. Interest on the part of partners led to some modification of budget and design, and ultimately to an extremely successful part of the project.

## Length of in-country engagement

In the Newcastle disease project in Myanmar, political and security difficulties meant that there were large gains (in trust and ability to engage with partners) from having a staff member able to spend prolonged periods in Myanmar.

# The project studies

# Development of a vaccine for the control of Gumboro in village and small poultry holdings in Indonesia (AH/2000/083)

**Jagoda Ignjatovic**

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| **Project number** | AH/2000/083 |
| **Project name** | Development of a vaccine for the control of Gumboro in village and small poultry holdings in Indonesia |
| **Collaborating institutions** | Indonesian Research Center for Veterinary Science (Bbalitvet); Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Animal Health Laboratory; University of Melbourne School of Veterinary Science |
| **Project leaders** | Australia: Dr Jagoda Ignjatovic, University of Melbourne<br>Indonesia: Dr Lies Parede, Bbalitvet |
| **Duration of project** | 1 January 2001 – 31 December 2007 |
| **Funding** | Total: A$1,103,846 (ACIAR contribution: A$575,704) |
| **Countries involved** | Australia, Indonesia |
| **Commodities involved** | Poultry |
| **Related projects** | AS1/1991/019 |

## Motivation for the project and what it aimed to achieve

Gumboro, or infectious bursal disease (IBD), is one of the most important poultry diseases in Indonesia. Infection with the IBD virus (IBDV) suppresses normal immune responses in chickens, meaning that the infected chick is unable to fight other infections, which are numerous in commercial poultry. In addition, a form of IBD, known as very virulent (vv) IBD and which is characterised by high mortalities, was suspected to be prevalent in Indonesia. For those reasons, all commercial poultry need to be vaccinated from an early age with live attenuated vaccines in order to prevent mortalities and immunosuppression. Even though a number of IBDV vaccines exist for control of less virulent strains, these vaccines are less effective against vvIBDV strains, particularly in Indonesia.

IBD is also an economically important disease of chickens in Australia, but because Australia is free from vvIBDV, collaboration was initially established between the CSIRO Australian Animal Health Laboratory, Geelong, and the Indonesian Research Center for Veterinary Science (Bbalitvet), Bogor. The aim was to characterise IBDV strains present in Indonesia and determine the prevalence of various forms of disease in village chickens and the small semi-intensive poultry sector, and to compare those IBDV strains with strains present in Australia. Another aim was to improve methods for differentiation of vvIBDV in order


Promotional pamphlet announcing the release of three new poultry vaccines, including live attenuated vaccine against infectious bursal disease.

to facilitate rapid differential diagnosis. Later in the collaboration an attempt was made to develop more-effective vaccine for control of vvIBDV in Indonesia, based on local IBDV strains, and part of this work was then carried out at the University of Melbourne School of Veterinary Science. The collaboration was initially supported by the Australian Agency for International Development, and then followed by the long-term involvement of the Australian Centre for International Agricultural Research.

## Outputs—what the project produced

### Technical

The key outputs produced by this project include:

- knowledge that vvIBDV forms are the predominant strains infecting poultry in Indonesia
- development, from three of the vvIBDV strains, of four 'master seeds' for production of intermediate, intermediate plus and mild IBDV vaccines
- reagents for differentiation of vvIBDV
- establishment of Australian diagnostic capability for vvIBDV, an exotic poultry disease, and enhanced research capacity in the area of IBDV
- a laboratory manual outlining the production and quality control of master seeds
- two publications in international journals
- one PhD thesis.

### Capacity

In addition, this project resulted in a significant increase in the scientific capacity of both the Indonesian and the Australian project teams. The main examples include:

- enhanced capacity of Bbalitvet and two of its scientists in IBDV diagnosis, vaccine development and evaluation
- establishment of Australian diagnostic capability for vvIBDV
- creation of a repository of Indonesian vvIBDV strains in Australia and Indonesia, which has been the foundation of all research and development undertaken on vvIBDV since then.

## Adoption—how the project outputs are being used

Four pilot batches of commercial vaccines have been produced from one master seed: three inactivated IBDV vaccines of various formulations and one live IBDV vaccine. These vaccines were produced in 2012 in Indonesia for use in commercial poultry. Reagents for differentiation of vvIBDV were also used in a diagnostic test for confirming isolation of vvIBDV.

Vaccination of broiler chickens via drinking water, using attenuated live infectious bursal disease virus vaccine developed in the project (Photo: Jagoda Ignjatovic)

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

As the vaccines have just been realised in Indonesia, there are no measurable changes or improvements for the poultry farmers who are their final users. However, future adoption of IBDV vaccines should benefit poultry farmers in all regions in Indonesia, as IBD is endemic in all provinces and IBD-associated losses are still of concern, indicating that control of the disease could be improved. Adoption of quality IBDV vaccines developed from a local strain is anticipated to reduce these losses.

Benefits for Australia include increased scientific expertise in handling vvIBDV, which is exotic to Australia. Expertise gained through the activities undertaken in this project is being used in other IBDV-related projects conducted in Australia. In addition, scientific data generated from comparisons of Australian IBDV strains and vvIBDV from Indonesia enabled the Australian poultry industry to clearly establish its freedom from vvIBDV. These data therefore provide the scientific justification for Australia seeking to maintain its vvIBDV-free status in international trade by restricting the import into Australia of live poultry and poultry products from countries where vvIBDV is present.

# The identification of constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific (AH/2001/054)

**Simon Reid**

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| **Project number** | AH/2001/054 |
| **Project name** | The identification of constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific |
| **Collaborating institutions** | Australia: Murdoch University (commissioned organisation); University of Melbourne (UM); Australian Government Department of Agriculture, Fisheries and Forestry; Children's Hospital Westmead; WHO/FAO/OIE Collaborating Centre for Reference and Research on Leptospirosis<br>Papua New Guinea (PNG): National Agriculture and Quarantine Inspection Authority (NAQIA)<br>Pacific Island Countries: Secretariat of the Pacific Community (SPC) |
| **Project leaders** | Australia: Dr Simon Reid, UM<br>PNG: Dr Ilagi Puana, NAQIA<br>Pacific Island Countries: Dr Steve Angus, SPC |
| **Duration of project** | 1 January 2002 – 1 May 2007 |
| **Funding** | Total: A$1,073,455 (ACIAR contribution: A$555,580) |
| **Countries involved** | Australia, PNG, Fiji, Kiribati |
| **Commodities involved** | Livestock (beef cattle, pigs, crocodiles) |
| **Related projects** | AS1/2000/009, LWR2/2001/038 |

## Motivation for the project and what it aimed to achieve

The project was initiated following a request from the Permanent Heads of Agriculture and Livestock Production Services, now known as the Pacific Heads of Veterinary and Animal Production Services, to the SPC in 2001 to examine the possibility that increasing livestock populations in many countries were contributing to greater public health risks. The particular issues related to the risks from animal waste and zoonotic diseases were highlighted. The SPC communicated the needs to ACIAR, which initiated two linked projects, 'Management of animal waste to improve the productivity of Pacific farming systems' (LWR2/2001/038) and this project, focusing on the risks from zoonotic diseases.

The choice of target diseases and livestock species was made during discussions between members of the project team, and was based on their relative importance and the ability to frame research questions. Likewise, the countries (PNG, Fiji and Kiribati) selected for research activities were chosen based on the perceived level of each of the aforementioned issues and the stage of development of their livestock and animal health systems.

Peter Wai'in (Manager, National Veterinary Laboratory) with blood samples from cattle at Trukai Farm, Erap, Papua New Guinea during project AH/2001/054 (Photo: Simon Reid)

The project had three main aims: 1. to determine the extent of spread of new or existing species of *Trichinella*, a parasite of pigs that can infect humans through consumption of undercooked pork; 2. to improve the capacity for surveillance of *Trichinella* and leptospirosis in the Pacific; and 3. to undertake field studies in PNG and Fiji to gain a better understanding of the epidemiology and potential impact of leptospirosis on livestock and the human communities that live close to them.

## Outputs—what the project produced

### Technical

A major output of the project was the generation of information that showed that livestock in the study sites were generally healthy and that the two zoonotic diseases that were the focus of the project posed low levels of public health risk. There is little or no evidence that *Trichinella* species are widespread in Fiji and Kiribati, and in PNG the parasite is restricted to wild pigs in the southern coastal provinces.

*Trichinella* became an issue at a commercial crocodile farm in PNG (Mainland Holdings farm, the largest of its type in the world) during the life of the project after it was identified in meat destined for export to Australia. Equipment and reagents provided by the project improved the capacity and efficiency of the National Veterinary Laboratory (NVL) to perform diagnostic services that enabled the crocodile farm to resume exports of meat to Australia.

Field studies conducted in PNG and Fiji during the project have provided unique information that describes the epidemiology of leptospirosis in livestock and domestic animals and its likely impact on animal and human health. This information showed that annual vaccination of cattle in PNG would reduce infertility due to leptospirosis and that the prevalence (and hence impact) of infection in smallholder livestock was low and did not warrant vaccination. The prevalence of leptospirosis in other livestock species and domestic animals in villages in PNG was also low and thus presented a low risk to public health.

In Fiji, surveys conducted in a community that experienced a significant outbreak of human leptospirosis showed a high prevalence of antibodies to *Leptospira* species in many species of livestock. Similar patterns were observed in the serovars present in dogs and humans (demonstrating common sources of infection). This was an important finding because effective vaccines are available for use in dogs, which may reduce the potential for dogs to act as a reservoir for human leptospirosis.

### Capacity

A highlight of the project was the success of two project staff from PNG who completed postgraduate training during the project. In collaboration with the project, Dr Nime Kapo completed the research component of his Master of Tropical Veterinary Science degree at James Cook University on *Trichinella* in highland pigs, and Dr Peter Waiín was awarded a PhD for his study of the epidemiology of bovine leptospirosis in PNG.

## Adoption—how the project outputs are being used

Tangible evidence of the adoption of project outputs can be seen in two areas. The first is the continued application of increased capacity at the PNG NVL. Equipment, reagents and training provided during the project have enabled the NVL to continue to work more efficiently to support export-accreditation testing for *Trichinella* in crocodile meat samples from the Mainland Holdings farm. In addition, equipment such as the microplate reader (for use with ELISA tests) that was provided by the project has enabled the laboratory to continue to perform serological tests after existing equipment became dysfunctional.

The other key area of adoption relates to the knowledge generated during the project concerning the epidemiology and public health risks of animal leptospirosis in PNG and Fiji. The information that vaccination for leptospirosis reduces the impact of the disease on the fertility of large commercial cattle herds has been used by producers to justify continuation of their vaccination programs. In Fiji, knowledge


Crocodile meat ready for export from Papua New Guinea (Photo: Simon Reid)

Eric Langlet demonstrating the grading process used by buyers of crocodile skins to select only the best for use in manufacture of handbags by fashion house Hermes. The handbags made from these skins could fetch up to US$200,000 each and there is a 2-year waiting list for them. (Photo: Simon Reid)

generated from surveys performed has been used during an ongoing process to develop a national strategy, initiated by the Ministry of Health, to improve control of leptospirosis. The erstwhile project leader (Dr Reid) is currently acting as the facilitator for this process.

One unintended, but beneficial, consequence of the study outcomes will be the likely increase in communication and collaboration between human and animal health staff in PNG and Fiji. In PNG, future collaboration was identified during a meeting with the national Department of Health that was conducted as part of the adoption study.

The adoption of the outputs from this project has been limited in part by the continued decline in cattle production (two farms that collaborated with the project have closed since the project ended) and the low priority given to livestock by the national government in PNG. This significantly reduces the incentive of the local industry to improve cattle production and hence make use of project outputs. In addition, the initial project design focused on acquisition of new knowledge relating to the likely impact of zoonotic diseases on animal and public health. While the project achieved this objective, the reality is that most zoonotic diseases have no significant direct impacts on animal health (and hence production) per se and, in the Pacific region, livestock-associated zoonoses are not commonly associated with human illness. For example, most cases of leptospirosis in Fiji are likely to be associated with rodents rather than livestock. Nevertheless, the information generated by the project was essential in providing evidence to confirm these observations.

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

The major outputs have been the generation of knowledge that cannot be directly applied by the communities that were involved in the project. This is because the major outcomes showed that the potential for livestock-associated zoonotic infections to affect the communities was small, and that they should therefore focus on other more important priorities.

Key project outputs are nevertheless relevant to major commercial cattle and crocodile producers in PNG and to the ministries of Health and Primary Industries in Fiji. In PNG, the future direct impact of the project has been to provide Mainland Holdings with access to diagnostic facilities at the NVL to provide export certification for their crocodile meat should they develop new export markets in the European Union. The potential future impacts in Fiji will occur once the knowledge from the project is applied to the development of a national strategy for the control of leptospirosis. It is likely to take several years for these indirect benefits to be realised.

# Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar (AH/2002/042)

Joanne Meers

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| **Project number** | AH/2002/042 |
| **Project name** | Control of Newcastle disease and identification of major constraints in village chicken production systems in Myanmar |
| **Collaborating institutions** | Australia: University of Queensland (UQ)<br>Myanmar: Livestock Breeding and Veterinary Department (LBVD) |
| **Project leaders** | Australia: Joanne Meers, UQ<br>Myanmar: Than Hla and Kyaw Sunn, LBVD |
| **Duration of project** | 1 January 2003 – 1 May 2008 |
| **Funding** | Total: A$922,062 (ACIAR contribution: A$534,138) |
| **Countries involved** | Myanmar |
| **Commodities involved** | Poultry |
| **Related projects** | AS1/1999/096, ASEM/1997/041 |

## Motivation for the project and what it aimed to achieve

Myanmar is ranked below many of its neighbours in terms of human development indicators. More than 70% of the Myanmar population reside in rural areas, with the majority earning income from their farming activities. Chickens are raised by most rural households in Myanmar and they provide an important source of food and income for these households. It has been estimated that village (backyard) chickens comprise 85% of the chicken population in Myanmar. Despite the importance of village chickens to the nutrition and livelihoods of Myanmar villagers, there was little information on the factors influencing the outputs of this production system. Based on studies conducted in other countries, it was expected that a combination of health and management issues would likely be reducing the productivity of village chickens in Myanmar, but details on the nature of these constraints were unknown before the commencement of the project.

The Deputy Director of ACIAR conducted a scoping mission to Myanmar in 2002 to identify, with the Myanmar authorities, agricultural research areas that had the most potential to facilitate rural development and benefit the rural poor of the country. Village chicken health and production was recognised as one of the key areas for research. The Deputy Director made contact with staff of the LBVD to discuss potential research projects. A follow-up visit to Myanmar was undertaken by the ACIAR Animal

A Myanmar village farmer with her chicken flock (Photo: Joanne Meers)

Health Program Manager and Dr Joanne Meers (UQ) to gain an understanding of LBVD's research needs and capacity. During this visit, the key research priorities of the department were established and a draft project proposal was produced.

The project aimed to improve the food security, nutrition and income of villagers in Myanmar by overcoming the major constraints to the productivity of village chickens. The broad major aim was to identify the constraints to village chicken health and production and assess the effectiveness of strategies implemented to mitigate those constraints. Other specific objectives were to enhance the production and distribution of Newcastle disease (ND) vaccines in Myanmar, and to develop extension materials to increase awareness amongst village farmers on village chicken health and production in general, and specifically to demonstrate to farmers the economic benefits of ND vaccination and chick management. Additional objectives were to characterise the ND viruses that were circulating in Myanmar and to increase the capacity of LBVD staff in several areas including vaccine production, pathology and diagnosis of poultry diseases, epidemiology and extension methodologies.

## Outputs—what the project produced

### Technical

The technical outputs of the project included the following:

- Through a series of well-designed and rigorously conducted field studies, the project provided the first detailed description of the village chicken production system in Myanmar, and the constraints on this system.
- The project introduced procedures to improve the management of chicks during their first 6 weeks. The procedures included protection from predators and environmental exposure through the use of creep feeders placed inside locally produced bamboo coops, and provision of supplementary chick starter feed for the first 3–6 weeks of life. These procedures were shown to produce a significant reduction in chick mortality, a marked increase in the number of chickens sold and the number of households consuming chicken meat, and a significant increase in income to the farmers after 6 months.
- The project demonstrated that the use of the ACIAR-developed I-2 ND vaccine resulted in reduced mortality due to disease in village chickens in Myanmar. Although the vaccine had been used in Myanmar before the project's activities, this was the first scientific assessment of the vaccine's impact in the field in this country.
- The project produced the first genetic characterisation of the ND viruses that circulate in Myanmar.
- The project introduced into LBVD an extension methodology and extension materials to demonstrate to farmers that simple and sustainable methods can improve the health and production of scavenging chicken flocks.
- Molecular polymerase chain reaction (PCR) diagnosis for the detection of ND virus was introduced into LBVD. Such technology was not available in the department before the research project. This output was not an objective in the original project proposal but was incorporated into project activities following requests from the Myanmar project team.

- The project produced a series of high-quality articles published in international and national journals, with further articles currently under review by a journal or in preparation. Oral presentations were made at international epidemiology and poultry conferences, and at the Myanmar Veterinary Association annual conference.

### Policy

Based on the research findings, the project contributed to a policy change through a modification to the official annual vaccination schedule for ND.

### Capacity

The capacity-building outputs of the project were extensive. Because of decades of relative isolation from the international scientific community, the staff of LBVD and other veterinarians and researchers who interacted with the project had struggled to keep up with advances in their disciplines. The capacity building of these veterinary scientists was achieved through both formal training courses and through personal experiences of working alongside Australian project staff. Although the original project proposal included only two capacity-building objectives (in diagnosis of poultry diseases and in extension methodologies), several other areas of capacity building developed during the course of the project and a capacity objective in epidemiology was included in the project extension proposal.

Capacity building in epidemiology and disease surveillance included formal training courses on aspects of survey design, collection of data, database management and storage of epidemiological data, outbreak investigations and data analysis.

A second key area of capacity building was in the use of molecular methods for the diagnosis of animal diseases. When the project commenced, there was no capacity in LBVD to conduct molecular diagnostic tests such as PCR, and there was limited capacity in these techniques in the country as a whole. The project delivered formal training on molecular diagnostics in Yangon and informal training in Australia, and provided equipment to the LBVD laboratories.

Capacity in vaccine production and quality control was increased through both formal training courses (in Myanmar and Laos PDR) and through interactions with Australian project staff. This training included the serological testing of vaccine responses, and serological diagnosis of ND and avian influenza.

The project increased capacity in extension methodologies at LBVD and in the district and township veterinary officers. There were limited extension capabilities at these levels before the project, and there was no defined extension department within LBVD. Training courses on extension approaches and activities were held, and extension resources were developed during the course of the project. These included flipcharts, calendars, pamphlets and posters. A program of farmer workshops was developed and conducted to discuss issues of chicken health and management.

Distributing coops and creep feeders for improved chick management (Photo: Joerg Henning)

## Adoption—how the project outputs are being used

The knowledge on the village chicken production system gained by the project, including that published in its scientific journal publications, has been used by a range of international agencies and Myanmar government departments (next and final users) to better understand the dynamics of this production system and in designing surveillance and control programs to combat H5N1 avian influenza. There is anecdotal information that the project findings have also been used by a number of non-government organisations in Myanmar (next users) when discussing programs on food security and poverty alleviation. The journal publications have been used by the international scientific community (next user), and have been cited a number of times in articles by others. Many of the extension materials developed by the project were adapted by non-government organisations and government departments to expedite the production of public health extension materials for H5N1 avian influenza control.

Molecular diagnostic methodologies have been adopted by the LBVD laboratories (final user). This adoption was boosted by the emergence of H5N1 avian influenza in the final years of the project. The international response to the H5N1 epidemic included the provision of training courses and equipment that built on the work of the ACIAR project. Molecular methods continue to be used for ND diagnosis in addition to their use in the diagnosis of H5N1 infection and a range of other animal diseases. The original methods introduced by the project have subsequently been updated as newer technologies become available.

The use of I-2 ND vaccine in village chickens has been widely adopted throughout Myanmar by end users (the village farmers). This program commenced prior to the project's implementation, but the project's activities helped to expand the production of I-2 ND vaccine to additional regional laboratories and to determine the effectiveness of the I-2 ND vaccine and the economic benefits of ND vaccination. Currently, the Myanmar authorities are reviewing policies on the production and distribution of veterinary vaccines from government laboratories, so this level of adoption may not continue into the future.

The procedures introduced to improve young chick management were promoted broadly through the course of the extension program. More than 1,500 households (end users) purchased equipment and feed for improved chick management. Although this extensive adoption occurred in the short term near the end of the project, it is difficult to assess if it has continued in the longer term. Circumstances allowed only one township to be visited during the adoption study visit, and at that site it appeared adoption had not continued. However, there was anecdotal evidence provided by one LBVD staff member that these procedures were still being conducted in some districts in the country. One important factor contributing to the lack of adoption of the improved chick management procedures was the inability to purchase chick starter feed in small amounts. In addition, economic modelling of the benefits of these procedures revealed that the sale value of grower chickens and the cost of commercial chick starter feed were important factors influencing the profitability of this intervention. Thus, continued adoption of these practices will be contingent on these various factors.

The capacity building from the project is being utilised in a number of areas. In particular, capacity in molecular diagnostics that was absent at the start of the project is now well embedded in the LBVD department (as noted above). This capacity is expected to continue to develop. The capacity building in epidemiology has also been retained and enhanced, with a very active and progressive Epidemiology Section now established in LBVD.

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

An evaluation of the intervention strategies applied showed that the village households that adopted the chick management procedures developed during the course of the project had, in months with sales of grower chickens, an increased income of approximately 2,500 kyat (about US$2.50). In addition, these households were shown to have increased rates of consumption of home-produced chicken meat after a period of 7 months when grower chickens were big enough to eat. The households that conducted ND vaccination had, in months with sales, increased sale income of approximately 780 kyat (about US$0.78). A recent economic analysis determined that the overall farm benefits (cumulative sum of the net differences compared with implementation of neither strategy) in the first 3 years after the introduction of the interventions was 13,190 kyat (US$13.20) for ND vaccination and 77,644 kyat (US$77.70) for improved chick management.

Overall, an increase in sales of grower chickens from those village households that adopted the interventions leads to an increased number of birds available in local markets, providing a more secure supply of this important food source in the community. The size of this benefit is moderated by the availability of only small volumes of chick starter feed (which affects adoption rates) and its cost (which affects the magnitude of impact). The cost of commercial chick starter feed is primarily influenced by global grain prices, which have risen substantially in recent years. The recent economic analysis further highlighted that the magnitude of the economic impact on village households of both the chick management changes and ND vaccination is also strongly influenced by the sale value of grower chickens. This price has local seasonal fluctuations due to changes in demand for the commodity that occur for reasons such as religious festivals or anticipated disease outbreaks. In addition, global grain prices have a major impact on costs of commercial poultry production, and this in turn influences the price of broiler chickens in the market. This might have flow-on effects on the value of domestic chicken meat.

It has to be considered that improved chick management requires greater investment than ND vaccination, hence the benefit:cost ratio in the economic analysis was lower than for ND vaccination. This necessary investment might make it difficult for some farmers to adopt improved chick management, and some solutions to this problem (e.g. microcredit schemes) might require further exploration.

The adoption of molecular techniques introduced by the project has improved the precision and timeliness of the diagnosis of veterinary diseases by the LBVD laboratories, in particular the diagnosis of ND and avian influenza. The beneficiaries of this more rapid and accurate methodology include commercial poultry farmers, village farmers and human public health officials. Rapid confirmation of a ND outbreak allows a swift response and implementation of vaccination programs. Rapid diagnosis of highly pathogenic avian influenza (HPAI) cases in poultry leads to quicker decisions on control and containment, which potentially prevents human exposure to the virus.

The extension activities that were conducted to promote knowledge and interest in village chicken keeping and health resulted in increased awareness of the importance of this livestock species, particularly to women in the village communities. The extension activities were inclusive of women and children, and the village meetings that were held brought communities together and became village events.

# Use and improvement of sugarcane germplasm (CIM/2000/038)

**Phillip Jackson**

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| **Project number** | CIM/2000/038 |
| **Project name** | Use and improvement of sugarcane germplasm |
| **Collaborating institutions** | Australia: Commonwealth Scientific and Industrial Research Organisation (CSIRO), Plant Industry; BSES Limited and CSR Limited<br>China: Yunnan Sugarcane Research Institute (YSRI); Guangzhou Sugar Industry Research Institute (GSIRI) |
| **Project leaders** | Australia: Phillip Jackson (CSIRO), George Piperidis (BSES)<br>China: Fan Yuanhong (YSRI), Li Qi Wei (GSIRI) |
| **Duration of project** | 1 July 2002 – 31 December 2007<br>(5 years plus a 6-month extension) |
| **Funding** | Total: A$3,419,522 (ACIAR contribution: A$1,411,755) |
| **Countries involved** | Australia, China |
| **Commodities involved** | Sugarcane |
| **Related projects** | CS1/1996/140 |

## Motivation for the project and what it aimed to achieve

This project commenced following invitations from the Guangzhou Sugarcane Industry Research Institute (GSIRI) and the Yunnan Sugarcane Research Institute (YSRI) to Phillip Jackson (CSIRO) to review their sugarcane breeding programs in China and explore opportunities for cooperation. From this, work on the application of DNA marker technologies for introgression of wild germplasm from China was identified as an area of high mutual interest and priority. Both Australian and Chinese breeding programs were keenly interested in introgression of new genetic diversity into their commercial breeding programs to underpin longer term genetic gains. This was because commercial sugarcane breeding programs trace back to a small number of original ancestors, and there is a perception that wild germplasm contains valuable genes, and traits such as vigour and tolerance to stresses.

The project aimed to conduct a collaborative research and breeding program between Australia and China, with complementary inputs from both, and from which both sides would share the outputs (knowledge, seeds, clones). This project was thus aimed at helping Australian sugarcane breeding programs just as much as those in China. From China, the key inputs were the basic germplasm and breeding program capacity (including crossing facilities). From Australia, expertise in some sugarcane breeding science, especially in use of DNA markers, was the most important input. Each side contributed resources to conduct laboratory work and field trials in its own country, to evaluate seedlings produced from crossing. Funding support from ACIAR helped obtain significant additional financial support from China for the work.

Chen Xuekuan (left), a plant breeder with the Yunnan Sugarcane Research Institute, and Phil Jackson (centre), CSIRO Australia, in discussion with a sugarcane farmer near Kaiyuan, Yunnan province (Photo: Phil Jackson)

Irrigated sugarcane growing in hilly country in the Yuanjiang region, Yunnan province (Photo: Phil Jackson)

Sugarcane industries are large and economically important in both China and Australia. In China overall, sugarcane is the sixth- or seventh-most important crop in economic value. In Australia, it is second- or third-most important (wheat being first, followed by sugar or cotton) depending on prevailing commodity prices. In China, sugarcane is of greatest relative importance in south-western China, especially in less-developed parts of Yunnan and Guangxi provinces, and its relative economic importance in these regions is increasing. About 70% of the 6 million people in Yunnan who are dependent on sugarcane farming as their main source of income are from ethnic minority groups, with most of these communities being generally poorer and less educated than other Chinese.

Wild relatives of sugarcane, especially *Erianthus* species and *Saccharum spontaneum*, are endemic in China. In the 1980s and 1990s, the Chinese Government made significant efforts to collect germplasm resources from throughout China, and the national collection of sugarcane-related germplasm is maintained in Yunnan by YSRI. Germplasm from China has not been used to any significant degree in sugarcane breeding programs outside China and, in common with programs in other parts of the world, most Chinese sugarcane varieties trace back to foreign clones.

The project had five components:

1. to assess genetic diversity in germplasm collections and select a core set of clones for breeding
2. to develop improved clones derived from wild germplasm with potential breeding value.
3. to evaluate DNA marker–assisted introgression of exotic germplasm in sugarcane improvement

4. to undertake genetic (G) × environment (E) studies between China and Australia to maximise mutual benefits from breeding collaboration
5. to help develop capability in YSRI and the Guangzhou Sugar Industry Research Institute (GSIRI) in technologies associated with sugarcane improvement, including application of molecular markers.

Associated with the capacity-development component of the project, many exchange visits between scientists and breeders in the partner institutes were arranged during the course of the project. From this, a range of technologies associated with sugarcane breeding, pathology and agronomy was discussed and extended.

Because of the need for lengthy selection and backcrossing, introgression breeding in sugarcane is recognised as being a very long term activity, with commercial benefits from released varieties taking up to 20 years. In this respect, the benefits from activity in the project were expected to arise gradually over time as good sources of parental material were identified in breeding programs in China and Australia.

## Outputs—what the project produced

### Technical

The four major technical outputs from the project, which correspond with the first four components of the project listed above, were as follows:

1. New knowledge and data relating to genetic diversity in wild germplasm collections in China

   This was done through DNA marker–characterisation of most of the clones in these collections. Some results have been published in the international literature. These results help form the basis for further sampling of the collection for characterisation of other important traits (e.g. response to water stress) or for breeding.

2. Genetic populations derived from wild germplasm in China provided to commercial breeding programs in Australia and China

   This was the most important output from the project. Two-hundred-and-two crosses involving clones derived from wild germplasm from China were successfully made during the project, and progeny verified with DNA markers. Progeny were evaluated in breeding programs in both China and Australia and, for further evaluation and for use as parental material, selected clones were made available at the end of the project to breeding programs in both countries.

3. New knowledge about using DNA markers in sugarcane introgression breeding

   Large datasets involving characterisation of backcross populations derived from *Erianthus* and *S. spontaneum* were generated and analysed. From these data, recommendations were made about further use of DNA markers in introgression breeding.

4. New knowledge about G × E interactions in Australia and China

   G × E interactions in Australia and China were evaluated, providing a better basis for ongoing collaboration and exchange of data and selected clones between Australia and China.

## Capacity

The key capacity outputs developed through the project were:

1. ability in China to identify ratoon-stunting disease (RSD) in sugarcane and to develop clean-seed schemes
2. institutional capability in China to undertake DNA-marker analysis for hybrid identification and for linkage and quantitative trait locus (QTL) mapping
3. capacity of YSRI to undertake quarantine for safe exchange of sugarcane germplasm between China and other countries, including molecular diagnostic tests for important diseases
4. new knowledge among breeders in China for a range of methodologies, particularly family selection and data analysis.

Some of these were not specifically targeted in the original project proposal but, in developing the project work plan, emerged as being important.

# Adoption—how the project outputs are being used

The major outputs from the project were designed to improve the conduct of the sugarcane breeding programs in China and Australia, which could, in turn, benefit the final users (farmers). Overall, to date, most of the technical outputs have been adopted and are significantly benefiting the breeding programs in each country but have yet to give rise to release of commercial varieties (for adoption by farmers) because of the long time needed in sugarcane breeding. Most of the capacity-building outputs are at a similar position, although final user adoption of clean seed has occurred and is beginning to have a large economic impact in farming communities. A brief commentary on the level of adoption of each of the main outputs to date is given below.

## Technical

1. New knowledge and data relating to genetic diversity in wild germplasm collections in China

   So far, this information has been used in only some small-scale scientific studies conducted at YSRI to characterise germplasm for physiological traits; notably in a study to examine response to water stress. It is also currently being used by YAAS to identify a core germplasm collection, which will help preserve and use the available germplasm. It is expected that this knowledge will be used in the future in other projects aiming to use the germplasm collection.

2. A wide range of genetic populations derived from wild germplasm in China provided to commercial breeding programs in Australia and China

   Clones from this output are being evaluated and used as parental material in commercial breeding programs conducted in both Australia (by BSES Limited and CSIRO) and China (by YSRI and GSIRI). To date, no commercial varieties have been released. However, it should be noted that commercial release was not expected at this stage, given the time frames involved in selection and evaluation of sugarcane varieties, and because it was expected that further backcrossing of selections to high-sugar-content parents would be needed before commercial varieties were delivered. Use of selected clones as parental material has occurred as expected in the original development of the project. At this stage it is too early to determine or quantify what the longer term impact will be on commercial breeding programs, but the availability of the material has led to a range of major follow-up breeding/research projects in both Australia and China, and which are currently in progress. Of particular significance is an initiative in breeding sugarcane for water-stressed environments, utilising materials developed.

**3.** New knowledge about using DNA markers in sugarcane introgression breeding

The approaches evaluated for using DNA markers in introgression breeding have so far not been adopted for development of commercial sugarcane varieties. In the final project report it was recommended that, due to the relatively high cost of using of DNA markers for introgression breeding in sugarcane, this should occur only when very high value backcross populations are identified and when cheaper and more accurate marker systems for sugarcane are developed. At this stage, work is proceeding in these areas (i.e. evaluation of backcross populations in both China and Australia, and in development of new marker systems in sugarcane in Australia), but has not yet reached a stage where adoption of the recommendations is appropriate. However, it is anticipated that this may occur within the next 3–4 years, given current progress in related projects.

**4.** New knowledge about G × E interactions in Australia and China.

The relatively high genetic correlations found between germplasm in China and Australia have provided impetus for continued exchange of elite clones between countries, and also exchange of seed. Three agreements for ongoing exchange of germplasm have been signed by Australia and China since completion of the ACIAR project, influenced significantly by the results from the project. However, while the study of G × E interactions provided support for development of these agreements, it is possible they may have been reached even in the absence of the study.

With staff at Yunnan Sugarcane Research Institute: (L–R) Li Mehui, Li Xiumei, Yang Lehua, Bai Yadong, Lu shuncai, Liu Jiayong, Zan Fenggang, Lu Xin, Jaya Basnayake (BSES Limited, Australia), Zhang Yubin, Phil Jackson (CSIRO Australia), Chen Xuekuan, Zhao Peifang, Yang Kun (Photo: Phil Jackson)

Conferring with sugarcane farmers from the Hani ethnic minority group in the Yuanjiang region, Yunnan province (Photo: Phil Jackson)

## Capacity

1. Capacity in China to identify RSD in sugarcane and to develop clean-seed schemes

   Development of clean-seed schemes has been adopted widely in recent years in Yunnan and is estimated to be having a large economic impact. Benefits in 2011 were estimated to be up to A$20 million and are expected to greatly increase in coming years as the adoption level rises.

2. Institutional capacity in China to undertake DNA marker analysis for hybrid identification and linkage and QTL mapping

   DNA markers are now used routinely in breeding programs in China for checking trueness of progeny. This simple application of DNA markers is potentially important for ensuring efforts are directed to true hybrid materials, which can be difficult to determine otherwise. DNA markers are not yet being used for QTL mapping and marker-assisted selection in introgression breeding in either Australia or China, due to difficulties and costs associated with doing so. These difficulties were not fully foreseen during the original development of the project. However, further development of marker technology is still occurring (in Australia), and application of this technology to germplasm from the ACIAR project may provide opportunities in coming years (within 3–4 years) given current progress. Uncertainties and questions nevertheless still remain regarding beneficial application of this output and technology to sugarcane introgression breeding.

3. Capacity of YSRI to undertake quarantine for safe exchange of sugarcane germplasm between China and other countries, including molecular diagnostic tests for important diseases

   This has allowed for exchange of cultivars between China and other countries, particularly in South-East Asia (six countries to date) and Australia. More agreements should occur in future. This is expected to have longer term benefits on performance of breeding programs.

4. New knowledge among breeders in China for a range of methodologies, particularly family selection and data analysis

   New methods of conducting selection, particularly family selection and some methods for sucrose analysis have been adopted in programs in China as a result of discussions during the course of the project and are being seen in China as having a positive impact.

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

To date, most of the outputs from the project have impacted on only the next users (breeding programs) and not yet on the final users (farmers and their communities). This is mainly due to the long time needed to develop sugarcane varieties, particularly via introgression breeding, the main focus of the project.

The adoption of clean-seed schemes for commercial production is already having an important impact on final users. The economic benefits of this technology sum to tens of millions of dollars currently, but are likely to be very much larger within 5 years (hundreds of millions of dollars per year), as adoption is expected to pick up with the recent installation of hot-water treatment facilities at many sites.

The capacity outputs appear to have impacted strongly on a range of areas of operation in the breeding programs in China. The areas of quarantine enabling international exchange of germplasm (with Australia and other countries), pathology, use of DNA markers, family selection and other selection methods were particularly highlighted in discussions with breeders in China as having a large effect on how they run their programs. To date, it is not possible to identify specific varieties that have resulted from these changes, but a longer term impact on program performance appears very likely.

A key output from the project was the germplasm generated from the crosses made between sugarcane and the wild species in China. Arguably the impact of the germplasm on the Australian breeding programs as a result of this project is greater than for the Chinese programs, because the latter probably would have used a component of the germplasm regardless of the ACIAR project. However, the ACIAR project was important in focusing efforts on true hybrid material (due to DNA checking of progeny) and this was important for the programs in China.

The lack of adoption and beneficial application of the DNA marker technology developed and evaluated in the project has been a disappointing aspect of the project so far, particularly considering the large amount of effort devoted to this area of work. This outcome is due to the technical difficulties and costs associated with this technology, particularly in sugarcane. Work in this area is ongoing, and researchers are still hopeful of applying outputs from this project for future sugarcane breeding as the technology improves in the future. However, adoption of this technology remains uncertain at this stage, and progress is slower than that envisaged when the project was originally developed.

# Taro beetle management in Papua New Guinea and Fiji (CP/2000/044)

**Sadanand Lal**

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| **Project number** | CP/2000/044 |
| **Project name** | Taro beetle management in Papua New Guinea and Fiji |
| **Collaborating institutions** | Regional: Secretariat of the Pacific Community (SPC)<br>Australia: Commonwealth Scientific and Industrial Organisation (CSIRO), Entomology<br>Papua New Guinea: National Agricultural Research Institute (NARI)<br>Fiji: Ministry of Primary Industries, Department of Agriculture (DoA) |
| **Project leaders** | Australia: Richard Milner, CSIRO<br>SPC: Sadanand Lal<br>Papua New Guinea: John Moxon, NARI<br>Fiji: Moti Lal Autar, DoA |
| **Duration of project** | 1 January 2002 – 31 December 2007 |
| **Funding** | Total: A$1,638,639 (ACIAR contribution: A$853,855) |
| **Countries involved** | Australia, Papua New Guinea, Fiji (SPC funded: Kiribati, New Caledonia, Vanuatu and Solomon Islands) |
| **Commodities** | Taro |
| **Related projects** | CS2/1994/050 |

## Motivation for the project and what it aimed to achieve

Taro, *Colocasia esculenta*, is a major root crop and staple food in many Pacific island countries (PICs). It is highly valued for its cultural, social and economic functions and has become an important source of income generation for the rural people.

Taro is the main income earner of many PICs and contributes greatly to national economies. In Papua New Guinea (PNG) it is a staple food in the lowlands and intermediate altitude areas where rainfall is well distributed throughout the year. In Fiji, taro, locally referred to 'dalo', is a major agricultural export commodity to Australia and New Zealand. The earnings from taro exports are in the order of A$25–30 million annually, which is significant given the relatively small size of the PICs' economies. The main consumers of taro in Australia and New Zealand are immigrants from Pacific islands.

The taro beetles, species of *Papuana* and *Eucopidocaulus*, are the main constraints for taro production in the PICs where the beetles are present. There are about 19 described species of *Papuana* of which nine are known to be pests of taro. *Eucopidocaulus tridentipes* is the sole pest species in this genus. The taro beetles are native to the Papuan region and all of the described species are present in PNG. One species was introduced into Fiji in 1984 and, because there are several cultivated and wild host plants there, became endemic.

Adult beetles feed on the taro corms, making tunnels that create entry points for secondary pests. Heavy infestations make the taro crop unsuitable for human consumption. Not surprisingly, there is zero tolerance for export markets as the beetle is a biosecurity risk to countries where it is not yet present.

Some of the members of the Burit women's group in East New Britain province, Papua New Guinea, who have enthusiastically adopted new technology for taro growing (Photo: Sadanand Lal)

Taro beetles also cause environmental problems. When gardens become infested they are abandoned. As a result, forest areas are cleared for new taro gardens. This practice leads to taro gardens being isolated in bushed areas away from dwellings. Abandoned and new gardens become vulnerable to soil erosion because, inevitably, taro gardens are established on sloping ground to avoid waterlogging.

The reduction in the taro supply to local people, due to unavailability and high prices, has shifted dietary habits; people are moving to relatively cheaper, imported commodities, such as rice.

The aim of the project on taro beetle management in PNG and Fiji was to develop a package of pest control practices that is safe, easy to use and environmentally sound. The long-term goal was that the recommended taro beetle management practices be integrated into sustainable cropping systems, reducing taro beetle damage in farmers' fields and thereby restoring supplies of a major staple food and trading in quality taro.

The project design was based on the achievements of a project of the Pacific Regional Agricultural Programme (PRAP) funded by the European Union. The outputs of the PRAP project laid the foundation for this research and development programme. The PRAP project highlighted three basic and positive control systems involving two biological control organisms, *Metarhizium anisopliae* (MA) and *Oryctes* virus (OV), and a chemical pesticide system.

A team of experts from the region provided the scientific and technical skills and local and regional experience necessary to solve the high-priority taro beetle problem.

## Outputs—what the project produced

### Technical

The most important technical output of the project was the pesticide recommendations developed for farmers so they could produce undamaged corms, promoting confidence in taro beetle management at farm level.

The following findings were made:

- MA can be cheaply mass-produced using low-tech methods appropriate for the PICs. Bioassay tests show that, while it is effective as an agent for biocontrol of taro beetles, it does not give sufficient level of control of the beetle when used in the field.
- OV has potential for control of the beetle population, but more research is needed on methods of its transmission to beetle populations in the field.
- Selective insecticides are the best option for the control of the beetles in the field. Use of two insecticides, imidacloprid and bifenthrin, gave best results, yielding over 95% undamaged corms at harvest.
- Synergy between low doses of imidacloprid combined with MA has very good potential for management of taro beetles in the field. This gives an opportunity for development of a commercial product for use in future.


Mrs Kiteni Kurika in a large taro field at the National Agricultural Research Institute station at Kerevat (Photo: Sadanand Lal)

- The problem of pesticide residues in harvested corms was resolved. No detectable residues of bifenthrin were found, while imidacloprid residues were well below the maximum residue limit for this chemical.
- A package of practice on taro beetle management in an integrated farming system was demonstrated to taro growers in the partner countries.

## Capacity

Capacity development and training featured strongly in the project.

- A subregional training workshop on the use of MA and OV for the management of taro beetles and other beetle pests in the region was conducted for technicians.
- The participants received background lectures on the development, biology and use of the two biocontrol agents.
- There was hands-on training in laboratory and field procedures on the use and handling of the two agents.

- Project field and laboratory staff also received training on experiment design and data recording and processing.
- In the latter part of the project, country staff were provided with instruction on participatory approaches to technology transfer to farmers.
- There was hands-on training in pesticide application and safety procedures.
- A modified farmer field school technique was developed for demonstrating the taro beetle management recommendations.
- An SPC taro beetle management technician undertook MSc studies at the University of Queensland.

## Adoption—how the project outputs are being used

Field visits to PNG and Fiji have shown that the recommendations of the taro beetle management project have been adopted by taro growers and the taro industry as a whole in both countries. In PNG, taro growers quickly adopted the new technology. This was indicated by an increased number of taro fields and in the enthusiasm of the communities in the taro industry in East New Britain (ENB) province. Taro in ENB and other parts of PNG was being abandoned as a crop because of the menace caused by the beetles. According to NARI taro beetle management staff, taro had previously not been grown and harvested for the community on Bougainville for over 40 years.

When one of the women's groups at Burit in the Gazelle district in ENB was visited, it was very encouraging to see the involvement of the whole family in taro plantations. These women were trained in the use of insecticides and the management of taro plantations as recommended by the project. After the training and demonstration of this new technology and harvest of their first crop, the women were convinced that taro beetle can be managed. The women's group said that they were very happy to be involved in the project and were encouraged to grow taro.

The women's group now has a business plan to grow taro continuously using the new technology and to sell their produce at local markets in ENB, to exporters in Port Moresby and to other outlets in PNG. According to Ms Rini-Palangat, the leader and spokesperson of the group, their entire taro production up to that time had been sold in local markets in ENB. The group has acquired more land for taro cultivation and, with the help of NARI, has established its own nursery to produce planting suckers using a mini-sett technique.

Income derived from taro has encouraged women to venture into other women's association activities such as floriculture, in which there is increasing interest in the region. Ms Rini-Palangat, who used to be a preschool teacher, became so motivated in taro production with the new technology that she is now a full-time taro farmer and leading the Burit women's group in its business venture.

A visit to a farm at Vunapalading Ward in Gazelle district found that Mr Penny Ase, a local farmer, had been using the new technology to grow taro on the same land for the previous four seasons. Mr Ase was so convinced with the technology that he had extended his taro plots within his cocoa plantation and was producing taro continuously. All his production is readily sold in the local market or from his farm gate. The income derived from taro compensates for loss of income from cocoa. Cocoa production in the area was recently badly affected by an outbreak of cocoa bod borer.

The new technology developed by the project allows a second planting of taro in the same field. (Photo: Sadanand Lal)

Taro is prominent in the World Bank–funded ‘Productive Partnership in Agriculture Project’ in ENB. According to Dr John Moxon, project manager of the Cocoa Project Management Unit, a taro market chain is being developed so that farmers get a quicker return and added income.

In Fiji, the commercial growers in the beetle-infested areas are using the recommended insecticides, but they are not fully conversant with the technology. There has been increase in sales of Suncloprid® (imidacloprid) and bifenthrin. A new formulation of imidacloprid, Nexus®, which has a lower concentration of the active ingredient, has since been registered. The farmers are not familiar with the correct dosage rate for the new formulation. Some farmers find it laborious to apply the insecticides on hilly ground and, as a result, are using the insecticides for dipping of the planting suckers before planting. There is no second application of the insecticides. In such situations there is high rate of rejection of taro while processing for exports, as observed during the visit. However, taro remains plentiful at local fresh produce markets in Fiji.

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

The project is having a substantial impact on rural communities in the ENB region in PNG, and in commercial taro production in the beetle-infested areas in Fiji. In PNG, taro production is now considered as an upcoming enterprise, either on its own or integrated with other traded commodities.

The project results are scientifically a very important solution to the menace of taro beetles to an important staple food crop in the beetle-infested PICs. In PNG, the project results have generated interest in research and development on other aspects of the taro industry. To meet the demand for taro varieties for commercialisation, a taro mini-sett technique for multiplication of planting material has been developed. Palatability tests have been carried out to select the preferred varieties for export of taro from rural areas to urban centres and other outlets. There are plans to establish and collect from gardens of all varieties of taro in PNG.

The beetle control technology appropriately fits into and supports agricultural policies to increase food and income for the rural people in PICs. The rural communities of the taro beetle–affected countries should see major economic and social benefits from improved taro quality and quantity per unit area. This will enhance food security, income generation and export earnings. In PNG, test runs have been conducted for export of taro from ENB and the Markham Valley to Port Moresby. There is already increased sale of insecticides and application equipment. Local entrepreneurs are emerging to meet the demands of the taro industry.

With this new technology, taro is now appearing prominently in the farming systems and vegetable gardens. Since taro can now be successfully produced, it meets the demands for social gatherings and cash from sales of taro for such events. Thus, income generation possibilities have improved at both subsistence and commercial levels.

In most of the Melanesian PICs, taro gardens are managed by women. Use of the new technology brings the taro gardens closer to dwellings, thereby reducing the time previously spent at distant gardens. Gardens nearer to dwellings encourage other family members to help in planting and maintenance. Increase in production will provide surplus for export, contributing to sustainable community livelihoods.

Taro in abundance from individual farming communities, for sale at the Kokopo, East New Britain, fresh produce market (Photo: Sadanand Lal)

The project results and this new technology reduce the need to clear primary forest for new taro gardens. This will allow farmers to increase the crop rotation cycle and reduce the area of land farmed. The major focus of the project was to develop management strategies that are environmentally friendly. The insecticides recommended are biodegradable, breaking down soon after application. This was revealed in the residue analysis of the soil samples from the experimental fields. If the insecticides are used according to the project recommendations there should be no pesticide-related problems.

Taro has a high nutritional value and other good health credentials. It is high in complex carbohydrates, fibre and other nutrients essential for good health. The physical activity derived from growing taro for family use, particularly by women, and consumption of good-quality complex carbohydrate by the family, can contribute towards controlling the epidemic of obesity in the Pacific region. Although highly recommended by nutritionists, and also preferred by Pacific communities, it is impossible for many families to consume taro as a regular staple food due to unaffordable prices and short supply in local markets. Encouraging backyard taro-growing promotes added benefits in terms of physical activity and keeping communities healthier and active. Therefore, this project not only provides tangible benefits to taro growers, but also adds value to small communities in terms of providing health and economic benefits to their families.

# Horticulture industry development for market-remote communities: Cape York and Samoa (HORT/2001/023)

**Irene Kernot**

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| **Project number** | HORT/ 2001/ 023 |
| **Project name** | Horticulture industry development for market-remote communities: Cape York and Samoa[1] |
| **Collaborating institutions** | Australia: Department of Primary Industries and Fisheries Queensland, now the Department of Agriculture, Fisheries and Forestry Queensland (DAFF Q)<br>Samoa: Ministry of Agriculture and Fisheries (MAF) |
| **Project leaders** | Australia: Rowland Holmes (DAFF Q)<br>Samoa: Philip Tuivavalagi (MAF) |
| **Duration of project** | 1 July 2003 – 31 December 2008 |
| **Funding** | Total: A$912,390 (ACIAR contribution: A$499,874) |
| **Countries involved** | Australia and Samoa |
| **Commodities involved** | Papaya, breadfruit, Tahitian limes, vegetables, taro |
| **Related projects** | ADP/1998/095; PHT/1988/044; PHT/1993/013; PHT/1993/877 |

1 This adoption study focused solely on Samoa.

## Motivation for the project and what it aimed to achieve

The availability of good information resources on which to base development decisions is taken for granted by farmers in developed countries. They have ready access to many sources of information along their supply chain, from input suppliers through to consumer research reports. Information is not so readily available for horticulture production in less-developed regions and the shortage can be acute for smallholder farmers in tropical and remote locations such as Cape York and Samoa. Both regions have a strong history of traditional knowledge passed on through story and family connections. This contributes to a lack of written information, so that when new technologies, pests and diseases, and new crops for new markets provide opportunities for development and production improvements, traditional knowledge systems struggle to provide support.

This project aimed to overcome this limitation to horticulture development. To achieve this, the project first investigated the information needs in the two regions and used that research to develop a user-centred information strategy. Working in partnership with MAF in Samoa, the project team conducted workshops in social research methods and information production. The workshops covered all aspects of information management, from writing for a target audience through to publication of books, guides and posters. The team then put in practice what they had learned, conducting farmer interviews and developing and distributing information products.

Tamoe Tautu and Mafutaga Tinifu inspect a jackfruit on Atele research station, Samoa. The station grows a range of fruit trees and provides material for distribution to farmers. (Photo: Irene Kernot)

## Outputs—what the project produced

The project developed a wide range of information products that are still widely used and continue to be developed. Most of the information is in the Samoan language and has been written for use by typical smallholder farmers.

- A Crops Division newsletter is now in its 10th edition and is produced quarterly. About 50 copies of the newsletter are printed and distributed widely to schools to keep agriculture teachers up to date with the research program. The link with schools is an important feature of the information system developed, as members of the new generation are much more active as information seekers.
- Posters outlining quality standards for taro, breadfruit and Tahitian limes were developed in consultation with the markets, to provide a guide on what to pack and send to export markets.
- Operational manuals on growing fruit for export were produced and used as training materials for producers. These comprehensive production guidelines cover taro and Tahitian limes.
- Leaflets on how to access export markets were produced. This 'export pathway' series covers taro, breadfruit, Tahitian limes and eggplant.
- Field guides on pests and diseases were produced for use by advisory officers.
- Crop notes for farmers were produced on topics such as papaya seed production. Taro variety identifier notes supported the release of new taro varieties from the breeding program.
- Promotional material was generated for field days and workshops, including a leaflet using the services of Manu Samoa, the national Rugby Union team, to promote the new taro varieties.
- Video clips are produced to support training and promote events. About 60 clips are available to advisory staff and farmers, and are also shown on the local television channel.
- A photographic collection is maintained and is available for use by staff.
- PowerPoint presentations are made for use in training workshops.

The work of the staff of the Information Unit in the Crops Division of MAF in producing and managing information is the main outcome from the project. The division has a well-respected Information Office able to support farmers, advisory staff and the Ministry, delivering specific products targeted at each client group.

## Adoption—how the project outputs are being used

Information products continue to be well used, recalled and appreciated by advisors and farmers.

The Information Unit actively searches for information and reports to use in its suite of information products. Much of the material is produced from research reports, and the unit also collects information produced in other Pacific nations to rewrite for Samoan farmers. Another source of information is the Secretariat of the Pacific Community, particularly for pest and disease notes. Often the language in

A trial crop of cabbages grown under cover using organic methods as part of a Sino–Samoa vegetable project. The information unit is liaising with the Chinese researchers to develop information products translated into Samoan. (Photo: Irene Kernot)

publications from other sources is too technical and, crucially, most material must be translated into the Samoan language. This ability to source and adapt material for local use was one of the planned outcomes of the project. This customisation of the materials has driven improved end-user adoption.

Adoption and use of the knowledge in desktop publishing, information production and information management systems is excellent, although information product development is restricted to the information unit for the most part, with few products developed outside the unit.

Advisory staff make use of the materials when working with farmers. The crop notes guides and leaflets are part of the advisors' tool kit; a reference collection to support them when they are in the field with farmers.

Farmers have used the material on export pathways, although access to overseas markets has been restricted with the result that, in recent times, very little product has been exported. Recently, the market for limes to the USA has opened and the government is hoping to grow that export market. Information on the export pathway and product quality requirements is essential to support the redevelopment of trade.

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

The project has made a significant difference to the way MAF views the importance of information products and the value that a dedicated information unit can bring to Samoa's industry development strategy. At least partly as a result of the project, the Information Unit within the Crops Division now works with the Research Advisory and Industry Development sections to produce a wide range of information products including leaflets, production manuals, posters, training presentations and videos.

Some of these materials were used in the lead-up to the South Pacific Games, where the plan to source locally grown produce for caterers lifted local production significantly. Although this impact was due to a number of factors, the integrated package developed by MAF to drive production growth included information packages and it can be argued that they contributed to the success of the Pacific Games food program. Sustained production growth will require that other limiting factors, such as the availability of planting material, are overcome.

The greatest restriction to the ability of the Information Unit to deliver greater impact through the development of information products is the limited resources available to it. Its team is small, with only three officers, and it requires better access to digital production capacity to take full advantage of new web-based information opportunities and make more use of television, radio and print media.

Tupito filming Mafutaga giving an introduction to a training video in the Information Unit at Nuu Research Station (Photo: Irene Kernot)

The development of a central information hub may bring more resources to the unit as the Ministry tackles the development of a call centre for farmers and the coordination of information dissemination.

Assessing the economic impact of the project is difficult. Information access is rarely the only factor limiting horticulture development and improved returns. Information supports the work of advisory officers and the commercial farmers who use it, rather than providing, by itself, the impetus for change. Without information the impact of the aforementioned work would be lower, but how much lower was not measured in this study. The Senior Advisory Officer is seeking more information packages for more crops, as she recognises the benefits to her advisors of the growing information resource.

The impact of the project can perhaps be summarised by a comment made about the current Senior Information Officer, Mafutaga Tinifu: 'She is a legend, when we want to know about information for horticulture we just go to her and she helps us'. The project has developed people and an information strategy that is valued by its users. The challenge will be to grow the capacity and help it meet the needs of farmers in the future.

# Assessing land suitability for crop diversification in Cambodia and Australia (SMCN/2001/051)

**Wendy Vance, Richard Bell and Seng Vang**

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| **Project number** | SMCN/2001/051 |
| **Project name** | Assessing land suitability for crop diversification in Cambodia and Australia |
| **Collaborating institutions** | Australia: School of Environmental Sciences, Murdoch University (MU); Department of Food and Agriculture, Western Australia—formerly Western Australian Department of Agriculture<br>Cambodia: Cambodian Agricultural Research and Development Institute (CARDI) |
| **Project leaders** | Australia: Professor Richard Bell, MU; Dr Peter White, Department of Food and Agriculture, Western Australia<br>Cambodia: Dr Seng Vang, CARDI |
| **Duration of project** | 1 January 2003 – 31 December 2008 |
| **Funding** | Total: A$2,123,177 (ACIAR contribution: A$915,463) |
| **Countries involved** | Cambodia and Australia |
| **Commodities involved** | Maize, soybean, mungbean, peanut, sesame |
| **Related projects** | CSI/1999/048, ASEM/2000/109, ASEM/2003/012. |

## Motivation for the project and what it aimed to achieve

In a significant milestone for food security and crop diversification, Cambodia achieved rice self-sufficiency in 1995. At about the same time, the Cambodian Government placed a priority on the need for alleviation of poverty in the country. During this period the farming population began to expand away from the lowland areas, into uplands. These factors meant that crop diversification emerged as an opportunity for rice-based and upland farmers to increase household incomes. Double-cropping entails the production of a non-rice crop in the dry (irrigated) or early wet (rainfed) season, followed by a main wet-season rice crop. The objectives of the original project were to determine the land suitability for diversification of field crops in upland cropping and in double-cropped rice-based systems in the rainfed lowlands of Cambodia. In Australia, the objective was to determine the land suitability for pulse production in south-western Australia.

The objective in Cambodia was achieved through development of methodologies of soil and land resource assessment and land capability assessment for five districts across the country. The data collected from these districts were combined with information from crop trials and farmer and expert knowledge in addition to spatial data collated. In south-western Australia, existing soil and spatial data were incorporated with farmer and expert knowledge to develop a methodology to determine land suitability for pulse production.

Mr Hin Sarith (CARDI) inspecting an experimental plot in Ou Reang Ov district, Kampong Cham province (Photo: Wendy Vance)

# Outputs—what the project produced

## Technical

In Cambodia, the project collated a range of soil, climate and spatial data from various organisations. These data were placed into a metadatabase and soil database for use by project members. As the project progressed, new data collected were added to the metadatabase, which remains an important repository of resources available.

Methodologies for soil survey, land capability assessment and laboratory analyses of soil physical properties were developed. These methods were important precursors to achieving the objectives of the project and provided robust methodologies to be used in future research projects that the CARDI Soil and Water Science Division participates in.

By using the methodologies developed, soil and landscape models were produced for five districts covering diverse upland locations in Cambodia. These models were the first models of upland landscapes produced in Cambodia. They identified the patterns of landscape, geology and soil type in these regions. The soils identified included those similar to types recorded in the previously produced rice soils manual, with one new soil type and an additional phase of another soil type identified. Importantly, it was recognised that while the soil types found in the upland areas were often similar to those in the lowlands, their position in the upland landscape meant that they were not recognised in the existing rice soils manual.

Land capability assessment for field crops and land suitability assessment for maize, soybean, mungbean, peanut and sesame were completed in three study districts. In addition to this, the limiting factors for the crops across the eight main soil types were identified as: soil acidity, waterlogging, low nutrient retention, low organic matter, surface crusting, low soil-water storage and erosion risk. Fertiliser rates for the crops were also formulated during field trials.

A National Soils Database was developed. Soil survey data from the project were entered in the database, together with any other available soil chemistry, physical and mineralogical data. In addition, soil survey data from other organisations and projects were sourced, so as to place all available records of soil survey across Cambodia into one database. The database allowed data input in English or Khmer and could be interrogated to create reports in either language. A manual for the use of the database was also produced.

From these studies the following documents were produced:

1. soil and landscape reports for five districts
2. soil and landscape maps of five districts
3. land capability assessment of three soil–landscape types
4. descriptions of the new soil type, Ou Reang Ov, and of a new phase of the soil type Kompong Siem Calcareous phase
5. methodology for land capability assessment, as a report and as a training manual
6. code books for describing soils in the field

Dr Seng Vang (CARDI) and the collaborating farmer showing the best experimental crop of sesame in the Tram Kak district, Takeo province (Photo: Wendy Vance)

7. farmer notes in Khmer, summarising outputs of soils and landscapes, crop suitability and limitations to field crop production
8. five papers in the Cambodian Journal of Agriculture
9. a manual documenting guidance on the operation of the National Soils Database.

## Capacity

CARDI staff developed skills in experimental research on field crops in upland areas, soil survey, and production of soil and landscape models. This required training in field experimental methods as well as geographic information systems and database systems. To complement this, laboratory methodologies were developed for soil physical methods of analysis.

The development of the National Soils Database and methodologies for soil survey and land capability assessment are all tools that can be utilised by organisations wishing to further enhance knowledge of soil types and land capability.

Through the on-farm experiments, 15 Provincial Department of Agriculture, Forestry and Fisheries (PDAFF) staff and 20 farmers were directly involved in the project. These collaborators developed knowledge of soil survey techniques, soil types and the suitability of specific field crops in upland areas of Cambodia.

## Adoption—how the project outputs are being used

Within the boundaries of the project's geographical focus there has been uptake in knowledge of soil types by all three levels of users: staff in CARDI and government departments; rural staff in the PDAFF; and farmers. The project has delivered technical reports, farm notes, maps and posters to PDAFF offices, and has also run technical workshops. Both extension staff and farmers have gained knowledge of soil types and crop suitability in the target districts. Those closely involved in the project as collaborators have a better understanding of the concepts than those not. Farmers who had experimental plots on their land were often a major source of the dissemination to surrounding farmers of information regarding soil types in the region and crop management. This was through informal discussion, farmers approaching them directly for information and at village-level farmer meetings. Participating farmers also distributed seed of improved cultivars. Nevertheless, the level of adoption was restricted to the district included in the project study area.

The project assessed the capability for the production of upland crops (maize, soybean, mungbean, peanut and sesame) in the target districts. Soil types were identified that were capable of producing each field crop. Extension officers and farmers can identify the suitability of the different soil types for upland

During the adoption study in Ou Reang Ov district, Kampong Cham province, Mr Touch Veasna (CARDI) and Mr Lenh Lonx and his family discussed current farming practices. (Photo: Wendy Vance) crop production. The uptake of production of these crops is dependent on the land capability, as well as commodity prices and farmers' perceptions of the intensity of crop management required. In Tram Kak district in Takeo province, the upland crops identified in the project were still being produced, with mungbean and peanut the preferred crops over maize and soybean. In Ou Reang Ov district in Kampong Cham province, soybean, maize and sesame were grown until 2009–10, but farmers then moved to the production of cassava, rubber trees and fruit trees due to better access to markets and higher prices for these commodities. In Banan district in Battambang province, maize is still the dominant crop produced, with smaller areas of the other upland crops targeted by the project. The reasons for moving away from production of the crops targeted in the project were cited as cost of fertiliser and insecticide, pest problems, drought and higher labour requirement for the more intensive field crops, weighed against higher prices obtained and assistance provided in accessing markets for alternative crops. Where market issues and commodity prices were the main drivers for an alternative crop choice, such as cassava, farmers were not averse to producing the field crops identified in the project if the prices received improved and compensated for the greater cost of labour and other inputs required.

The Soil and Water Sciences Division of CARDI has continued to complete soil profile analyses for internal research projects, as well as land suitability assessments for the programs of social and economic land concessions, as requested by the relevant government department. Within the General Directorate of Agriculture (GDA), the Department of Agricultural Land Resource Management is involved in soil survey and land capability assessment using methods similar to those developed in the project.

The National Soils Database is maintained by CARDI. New soil profiles collected during CARDI research are input to the database and the database has been provided to requesting agencies. No new profiles from other agencies have been added to the database since the completion of the project, and few organisations have requested access

The methodologies, outputs and recommendations developed in the project have been identified in two government strategy documents: 'Best Practices in Sustainable Land Management' and the 'Strategy for Agriculture and Water 2010 to 2013' (SAW). This indicates that the project outputs are supported at a policy level. Indeed, SAW gives a timeline for their inception, and associated completion milestones. The strategy specifically recommends that:

1. land capability classification needs to be completed nationwide using the methodology developed during the project by CARDI
2. soil classification surveys should be continued, based on the Cambodian Agronomic Soils Classification system
3. the National Soils Database developed during the project by CARDI should continue as a future storage facility for national soil survey data and, as such, the existing database should be enhanced and utilised as part of this strategy
4. land capability for the main soils in upland farming systems for field crops should be assessed and a manual for classification of upland soils developed.

Adoption will be contingent on government organisations implementing the program as outlined in the SAW program. The Department of Agricultural Land Resource Management is currently achieving some of these directives in terms of soil survey, land capability and land use surveys, but is constrained by inadequate funding.

Farmers and extension staff identifying the soil type in Ou Reang Ov district, Kampong Cham province, led by Mr Hin Sarith of CARDI (Photo: Seng Vang)

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

The final users of the land capability and soil survey information were farmers in the districts. They have gained knowledge about the soil types capable of growing field crops and they recognise the soil properties critical for these crops. These farmers have an increased crop choice for production in the early and main wet seasons, and can potentially add a field crop into the yearly crop rotation. Farmers suggested that a benefit to them of the project was the improvement in knowledge of soil types and fertiliser requirements, and on crop agronomic management of the target crops on the different soil types. Farmers often continued to follow agronomic management techniques used in the experimental crops. However, the techniques were altered to suit the resources available to the farmer. Benefits to farmers included improved incomes, which in some cases translated into improved homes and purchases of land for further agricultural use. In addition, they were often then more open to trying new crops.

The continued assessment of soil distribution and land capability across districts and for a variety of commodities is dependent on research priorities and project funding. Current projects at CARDI have not required a program of land capability assessment and soil survey. The framework identified in the SAW strategy documents indicates that the Cambodian Government identifies land capability assessment nationwide and the related tools for implementation (soil survey, soil and land unit maps, soil database) as having high priority. It is expected that progress towards completion of the district-by-district assessment of land capability will continue, as has been demonstrated by the current activities of the GDA Department of Agricultural Land Resource Management.

Improved scale-out of the successes of the present project at district level would probably require an integrated effort on crop suitability and best-practice agronomy for selected crops, supported by value-chain studies and interventions.

# Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia (SMCN/2002/085)

**Philip Moody**

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| **Project number** | SMCN/2002/085 |
| **Project name** | Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia |
| **Collaborating institutions** | Australia: Queensland Department of Natural Resources and Water (QDNRW)<br>Vietnam: Institute of Agricultural Sciences of Southern Vietnam (IASSV) |
| **Project leaders** | Australia: Dr Philip Moody, QDNRW<br>Vietnam: Dr Phan Thi Cong, IASSV |
| **Duration of project** | 1 January 2004 – 31 December 2007 |
| **Funding** | Total: A$675,090 (ACIAR contribution: A$435,844) |
| **Countries involved** | Australia, Vietnam |
| **Commodities involved** | Upland crops, maize |
| **Related projects** | CTE/2000/165, LWR1/1994/014 |

## Motivation for the project and what it aimed to achieve

In the central highlands of Vietnam, soils have been degraded by slash-and-burn subsistence agriculture and extensive deforestation, leading to erosion and fertility decline. Poverty is widespread and the national government of Vietnam has encouraged the local people to settle in villages and turn to permanent agricultural production. However, there is little technical information available on practices required for long-term productivity of upland soils, and there is no cultural experience of permanent agriculture within the ethnic minority people. Current technical advice on nutrient management follows a crop-specific recipe book approach of 'one size fits all', without reference to intrinsic soil constraints (such as drainage) or soil fertility status.

This project aimed to validate a decision-support framework (Soil Constraints and Management Package: SCAMP) that allowed basic soil information to be interpreted in terms of soil constraints to productivity and to be synthesised into management strategies appropriate to maintaining the long-term productivity of upland soils. The ultimate aim was to encourage site/soil-specific management by smallholders to maximise the productive capacity of upland soils within their intrinsic capabilities.

## Outputs—what the project produced

### Technical

- The SCAMP manual (ACIAR Monograph No. 130[1]) was produced and translated into Vietnamese. This manual describes how to observe and measure site features such as landscape position, slope and land use, and soil characteristics such as drainage, texture, pH etc. The manual explains how these site/soil characteristics can be interpreted in terms of soil constraints to sustainable production and documents management strategies to mitigate these constraints. In essence, the SCAMP manual is a technical reference source for the development of site/soil specific management.
- Maps of soil properties/constraints were produced for point data in Vietnam and spatial raster data in Australia.

### Capacity

The project developed capacity in Vietnam in the following areas:

- Sustainable soil management *(an intended outcome)*

  The SCAMP manual in Vietnamese provided resource material that was used extensively by the Institute of Agricultural Sciences for Southern Vietnam (IAS) project team of scientists and technicians to train provincial extensionists, champion farmers and project staff of non-government organisations (NGOs) how to determine basic soil properties such as texture, what these properties mean, and the management implications.

1 Moody P.W. and Cong P.T. (2008) Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils. ACIAR Monograph No. 130. Australian Centre for International Agricultural Research: Canberra.

Additionally, soil assessment based on the SCAMP methodology was used to design appropriate treatments at the core field trials of both this project and the World Vision Agricultural Development Project (ADP) in Binh Thuan province.

- Application of geographic information system (GIS) technology *(a serendipitous outcome)*

  It was recognised early in the project that there was little knowledge at IAS of the use of GIS to produce maps of soil properties and constraints. With the aid of Crawford Fund sponsorship, a spatial systems officer from the Queensland Department of Natural Resources and Water delivered a 2-week training course on the application of MapInfo using the SCAMP database as the source data. IAS scientists applied this training by producing constraint maps of the soil information collected in the project.

- Laboratory quality assurance (QA) and quality control (QC) *(an intended outcome)*

  The soil and plant analysis laboratory at IAS serviced the analytical requirements of the project field trials, but had no formalised QA/QC procedures in place. Through funding from ACIAR Contract C2006-001, 'Advisory support for ACIAR-sponsored labs participating in the ASPAC (Australasian Soil and Plant Analysis Council) Proficiency program', the IAS lab (together with several other South-East Asian labs involved in ACIAR projects) was sponsored to participate in the Inter-Laboratory Proficiency Program of ASPAC. The IAS lab consistently gained certification for several analyses.

- Staff training *(a serendipitous outcome)*

  Ms Do Thi Thanh Truc from IAS was granted a Crawford Fund Training Award and was instructed at the Queensland Department of Natural Resources and Water laboratory in the methodology and interpretation of rapid field-based soil analyses used in SCAMP.

  Mr Nguyen Quang Chon, the IAS scientist responsible for the day-to-day management of the project's field trials, was selected for a John Allwright Fellowship to complete a PhD in soil chemistry at the University of New England, Australia.

Dr Phan Thi Cong of the Institute of Agricultural Sciences of Southern Vietnam describing soil properties in the field to extensionists and World Vision project field staff. Measuring and recording soil properties is necessary for assessing soil constraints to productivity using the SCAMP framework. (Photo: Phil Moody)


Demonstration field experiment in Tay Ninh province, Vietnam, where SCAMP-informed treatments were compared with local farmer practice in terms of productivity and profitability (Photo: Dr Phan Thi Cong)

## Adoption—how the project outputs are being used

- Sustainable soil management *(capacity utilisation—next user; adoption—final user)*

  SCAMP training has been provided by the IAS project team to over 200 next users comprising champion farmers, extensionists and NGO project officers. Although the training of the final users (smallholders) by the extensionists has not been quantified, it is known that more than 800 final users have been trained by the NGO project officers.

- Application of GIS technology *(capacity utilisation—next user)*

  Maps of point data for a range of soil properties have been produced by the IAS staff trained in the application of GIS.

- Laboratory QA and QC *(capacity utilisation—next user)*

  With the current ACIAR sponsorship of the IAS laboratory in the ASPAC Inter-Laboratory Proficiency Program, the laboratory has consistently gained certification for several soil analyses and has active QA/QC processes in place.

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

The core field experiments in Gia Lai province demonstrated the financial benefits of adopting a site/soil specific approach to nutrient management based on a SCAMP assessment, with consequent flow-on benefits to household income and the maintenance of a sustainable farming system. Project staff in the ADPs of World Vision recognised the benefits of SCAMP assessment for identifying cropping systems appropriate for specific soil/site situations. They have adopted SCAMP assessment of the soil resources of their focus communes as the first step in promoting the adoption of sustainable cropping systems. While the adoption rate has not been assessed, these cropping systems would be expected to have flow-on benefits in terms of food security and water quality.

# Herbicide use strategies and weed management options in Filipino and Australian cropping (SMCN/2003/011)

**Rick Llewellyn**

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| **Project number** | SMCN/2003/011 |
| **Project name** | Herbicide use strategies and weed management options in Filipino and Australian cropping |
| **Collaborating institutions** | Australia: University of Western Australia (UWA); Commonwealth Scientific and Industrial Research Organisation (CSIRO)<br>Philippines: Philippine Rice Research Institute (PhilRice) |
| **Project leaders** | Australia: Dr Rick Llewellyn, CSIRO (2004–06); Professor David Pannell, UWA (2006–08)<br>Philippines: Dr Madonna Casimero, PhilRice (2004–08) |
| **Duration of project** | 1 July 2004 – 30 June 2008 |
| **Funding** | Total: $A906,041 (ACIAR contribution: A$512,041) |
| **Countries involved** | Australia, Philippines |
| **Commodities involved** | Rice |
| **Related projects** | CS1/1996/013 |

## Motivation for the project and what it aimed to achieve

Rice growers in the Philippines and many other regions of South-East Asia face increasing weed management challenges. These have been caused by a range of factors, including increasing labour costs leading to less hand-weeding, less reliable availability of irrigation water and a related increase in the use of direct seeding of rice. Compared with transplanting of rice crops, direct seeding requires much less labour but can greatly increase weed pressure. A result of these changes in the farming system is increased reliance on herbicides for weed control.

In the major irrigated rice-growing regions of the Philippines, where typically two or three rice crops per year are grown, there is the potential for the annual number of herbicide applications to rise rapidly. When herbicide reliance increases, so does the risk of weeds becoming resistant to herbicides. This project aimed to 1. evaluate the risk of herbicide resistance in major rice-growing regions of the Philippines and, at the same time, work in partnership with farmer groups to 2. test, evaluate and adapt integrated weed management (IWM) practices that can reduce herbicide reliance. Despite emerging concerns, very little work had been done to tackle these problems in the Philippines.

Unlike many other rice-growing regions in the world, herbicide resistance had not been widely reported in the Philippines. With herbicide use intensity increasing rapidly, a major goal for this study was to pre-emptively develop understanding and a local capacity around herbicide resistance and its management. Through the course of the project it also became evident that other weed population shifts associated with direct seeding were of importance, including increasing prevalence of weedy rice.

The 4-year project was designed to combine local farming systems expertise in the Philippines with Australian expertise in IWM, herbicide resistance and resistance management. The partnership involved researchers from the University of Western Australia, the Philippine Rice Research Institute (PhilRice) and, later, the Commonwealth Scientific and Industrial Research Organisation, Australia. In the Philippines, the project utilised PhilRice's strong networks for regional engagement to partner with farmer groups and local government representatives from the intensive rice-growing regions of Iloilo and Nueva Ecija provinces. In the short term, the project had the objective of increasing farmer adoption of profitable crop management practices that reduced weed populations and increased yields. The longer term objectives included increased understanding of the herbicide-resistance threat and the capacity to deal with that threat, both through greater research capacity and better adapted IWM practices.

## Outputs—what the project produced

The project generated several major outcomes, some of which were not foreseen. It raised awareness of not only the risk of herbicide resistance but also its existence in farmer fields in major rice-growing regions. Initial surveys, involving over 400 farmers, confirmed the intensity of herbicide selection pressure on major weeds with a known propensity for herbicide resistance elsewhere in the world. The first herbicide used by Iloilo and Nueva Ecija farmers after adopting direct seeding of rice was typically butachlor, which had been used by over 60% of farmers for more than 8 years on average. Later, they had typically shifted to herbicide

Farmers discussing weed issues with PhilRice researchers during an adoption study visit to Bibiclat, Aliaga municipality, Nueva Ecija province, in January 2012 (Photo: PhilRice)

products that contained a combination of two herbicide types — butachlor+propanil — to gain greater efficacy on a broader spectrum of weeds. Over 80% of the farmers had used butachlor+propanil for more than 7 years on average. This in-depth analysis of farmer weed and herbicide management informed the later development of a bioeconomic decision-support tool for considering long-term IWM strategies for managing *Echinochloa* spp. (Barnyard Grass), the most important weed in rice fields in the Philippines.

A major result from the project was the first confirmation that the intense herbicide selection pressure in some Philippines' rice fields had led to Barnyard Grass becoming resistant to the important herbicides butachlor and propanil. This included populations with resistances to both the chloroacetamide (butachlor) and amide (propanil) group herbicides; only the second reported case of this form of multiple resistance in the world. The work was published by Juliano et al. (2010) in the International Journal of Pest Management.

By confirming the presence of herbicide resistance for the first time, the research had produced evidence for why declining herbicide performance was being reported by some Filipino farmers. The project's farmer survey research had confirmed that there was typically no awareness among the farmer population of the potential for weeds to evolve resistance to herbicides. There are several possible reasons for poor herbicide performance, such as factors associated with variable quality of application and the herbicide product, but herbicide resistance was not being considered as a possible reason when declining herbicide performance was being experienced.

While herbicide resistance was still not a high-priority issue among farmers, the project's research had produced the impetus to raise awareness among researchers, extension agents and farmers of the potential presence of herbicide resistance, and the risk associated with current levels of herbicide reliance. It also encouraged the development of ongoing expertise, capacity and protocols at PhilRice for conducting herbicide-resistance research, extension and testing. The project led to two PhilRice researchers gaining ACIAR-supported PhDs; one developing a bioeconomic tool for evaluating integrated weed and herbicide management strategies in Philippine rice systems, the other evaluating opportunities to improve adoption of complex multicomponent technologies such as IWM by Filipino rice growers. Other PhilRice researchers gained additional international training in herbicide resistance and weed management.

An unexpected outcome of the project was the confirmation that weedy rice in farmer rice fields was far more extensive than previously realised. Weedy rice is a major weed issue in many rice-growing regions of the world. Field surveys in the Nueva Ecija and Iloilo study regions found its occurrence in the different municipalities to range between 3% and 75% of fields, while the severity of infestation within fields ranged between 5% and 60% of plants present. Morphological studies showed large variation across the biotypes, but the weedy characteristics of early maturity and production of high seed numbers were common. The findings were communicated nationally and through international networks for which weedy rice is of increasing concern.

By far the most salient weed management issues for Filipino rice growers involve control of weeds to increase the profitability and production of current rice crops. This was the primary focus of the project's work on IWM practices. Participatory on-farm trials with local village-based groups were conducted at Barotac Nuevo and Dingle in Iloilo and Aliaga and Rizal in Nueva Ecija. This work produced locally adapted and understood practices that were developed and presented as 'IWM'. The core component practices are tabulated below.

### Integrated weed management (IWM) and farmers' common weed control practices as compared in on-farm trials.

| Activities | Common farmer practice | IWM |
|---|---|---|
| Land preparation | 1–2 weeks period (1 ploughing, 1 harrowing, and levelling) | At least 2–3 weeks period (1 ploughing, 2 harrowings, and levelling) |
| Herbicide application | Pre- or early post- and late post-emergence or hand-weeding at 30–45 days after seeding | Pre- or early post-emergence |
| Water management | Greater use of flooding for longer periods | Alternate wetting and drying |
| 'Weed control action indicator' (a simple threshold guide for post-emergent herbicide application) | Not used | Used at 15, 30 and 45 days after seeding |

The implementation of the practices in trial fields produced reduced weed weights, increased yields and led to higher profits, and reduced the number of herbicide applications using an IWM strategy. Examples of local adaptation included flexibility around the time of land preparation in localities at the tail end of the irrigation system (e.g. Barotac Nuevo in Iloilo and Aliaga in Nueva Ecija) where irrigation water availability was less reliable, and the trialling of row seeding using a drum seeder in some barangays (local communities). As part of the project's strategy to integrate weed management considerations as much as possible into general crop and farm management, the IWM trials were included as part of season-long farmer field schools on integrated crop management that were run in each barangay.

## Adoption—how the project outputs are being used

The project generated new information and understanding about the weed management threats of herbicide resistance and weedy rice, as well as demonstrating locally adapted and improved weed management practices with the potential for immediate adoption. Since the project ended, the resulting knowledge has been integrated and delivered into PhilRice and international weed management initiatives. The weedy rice findings led to a joint extension initiative with the International Rice Research Institute (IRRI) and a key role for PhilRice weed researchers in an ongoing research project. The herbicide-resistance and farmer weed-management studies have been integrated into a bioeconomic IWM decision-support tool, 'Resistance Integrated Management (RIM-Phil)', as part of a PhD completed by one of the PhilRice project participants (Beltran et al. 2012a, b). The weed management findings of the project have been incorporated into PhilRice's 'Palay Check' and rice-sufficiency programs, and delivered to over 370 regional extension staff for subsequent local delivery. The weed management findings were also incorporated into PhilRice's large on-site field extension program which, based on PhilRice records, has reached over 50,000 participants since 2007.

By the end of the original project in 2007, 75% of participating growers had adopted IWM components on their whole farm area. Typical of more complex innovations, uptake by non-participating neighbouring farmers was much lower and slower, having reached only around 10% at that time. A study of the drivers of adoption of IWM conducted by Barroga (2010) found that farmers who adopted tended to have larger farms and greater access to credit but participation in project training was the major factor in explaining adoption at that time.

On revisiting the participating barangays in 2012 and interviewing farmers and local extension personnel it was found that, among the participating barangays, adoption of key components of the IWM package had continued at high levels. A successful strategy of the project was to incorporate the weed management extension activities within broader crop management programs. This was informed by experience in Australian cropping, where successful extension of weed management practices has recognised that the most relevant goal of farmers is improved crop production, not just reduced weed levels or avoiding herbicide resistance. However, this cropping systems approach does make attribution of impact of adoption more difficult, particularly for some practices such as improved land preparation, which is important for weed management as well as other crop establishment objectives.

Based on anecdotal reports from participants and regional extension staff, adoption by attendees at the review workshops had continued at the high levels (approximately 90%) found in the comprehensive adoption studies conducted near the end of the project. It was clear that there was very strong recall of the project messages in terms of IWM components, principles and recommended methodology. Based on workshop feedback, improved and extended land preparation before sowing was considered the most important and therefore became the most commonly utilised of the practices. Improved water management for weed control was also important, but in some local areas, such as those at the tail end of the canal system, its regular application was affected by suboptimal irrigation availability and other seasonal factors. Routine use of the threshold-based weed density indicator (to help decide if post-emergent herbicide application is necessary) was clearly the least adopted component of the suite of IWM practices that had been recommended as part of the project. However, strong recall of the principles and rules of thumb (e.g. 5% threshold) was evident. A common reason given by participants for lower use of the weed control threshold indicator was generally lower in-crop weed densities following the improved weed management during crop establishment. Reduced herbicide use was reported at all workshops, with a 50% reduction commonly cited.

Shifts in crop production practices over the 5 years since the project ended were also reported as influencing current weed management practices. These included improved irrigation water supply for some farmers, increasing adoption of hybrid seed, greater use of rice transplanting by some farmers and greater use of higher quality certified seed.

Although some reports of practice change by neighbours of project participants were much higher than those measured at the end of the project, the constraints associated with diffusion of a relatively complex, multicomponent technology remain apparent. In some localities such as Rizal, over 80% of neighbouring farmers were reported by farmers and local government sources as adopting improved land preparation, assisted by synchronised local planting regimes and a neighbouring project that had also promoted improved land preparation. Neighbouring Palay Check training, which now includes IWM, was also associated with cases of higher adoption by neighbouring farmers. However, estimates of practice change among non-participating neighbours were as low as 5% in other barangays.

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

The impacts reported by those who have adopted the practices and have had the opportunity to use them on their farms for several seasons are centred upon increased yields and reduced herbicide use. During the project, increases in net returns from IWM-treated plots compared with plots treated with common district practice were typically estimated to be in the 15–40% range. It was not possible to conduct an analysis of farmers' current net returns under an IWM system, but participants commonly reported a 20% yield advantage compared with previous practice. This is likely to capture many changes from when the project started, such as new crop varieties and improved seed quality. Reduced weed densities and, consequently, reduced herbicide costs, were the primary reported impact, although these cost reductions need to be considered relative to the additional cost of extended land preparation. Overall, the low level of disadoption by project participants suggests ongoing positive impact.

Large-scale impact relies upon practice change from those well beyond the initial participant group. As described in the adoption literature and found in the study of early adoption outcomes related to this project (Barroga 2010), the spread of adoption among neighbouring farmers and districts is constrained by the location-specific learning requirements and the difficulty that participating farmers have in simply sharing relevant information relating to more complex multicomponent change with fellow farmers. A common comment from project participants during the workshops was that the field activities could have run over fewer years and achieved a similar level of adoption among participants. This is supported by the rate of adoption observed during the project. This suggests that there may be the potential to generate greater overall adoption by trading off at least some multi-year local adaptation/demonstration time to allow more farmers to experience at least some level of on-farm extension.

In terms of capacity development and informing future research, development and extension, the project has had major impact. Dr David Johnson, the weed research leader at IRRI, reported that while weed science capacity was generally not strong in South-East Asia, the PhilRice team had developed into the strongest in the region and has been able to continue to develop key elements of the original project. The confirmation of multiple herbicide resistance in weed as widespread as Barnyard Grass was described as a 'significant finding' and has made a difference to planning of future weed and herbicide research and development projects. The project findings and newly developed capacity for research into weedy rice has led to ongoing research at PhilRice through IRRI.

The benefits of having an influential in-country project leader in a position to incorporate weed management components into ongoing large national initiatives for improved cropping systems means that project information and experience continues to reach a large audience. The ongoing impact that has been experienced well beyond the participating villages can be largely attributed to the integration of the project findings into PhilRice's well-developed national extension programs. These include programs such as the national Palay Check and train-the-trainer programs that have delivered integrated weed and herbicide management to over 500 regional rice extension officers since the project ended. Further, PhilRice's extensive program of field days across the Philippines has included project-derived weed management information that has been delivered to over 50,000 rice farmers since the project ended.

In summary, the project generated high levels of practice change among participants and this has been sustained with considerable enthusiasm over the 5 years since the project ended. The potential for on-farm participative extension to lead to adoption and sustained use of IWM practices to reduce herbicide reliance has been demonstrated. Extensive diffusion of IWM based on imitation by neighbours cannot be relied upon but, under some circumstances, extensive adoption of individual components of IWM by neighbouring farmers will occur. The project has had substantial capacity-building impact. Its findings developed new understanding of potential threats to rice production in the Philippines and, through subsequent development of research capacity, it has developed a strong and respected weed research capability.

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