Country Profile

Cambodia, Laos and Thailand

November 2005

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. ACIAR commissions collaborative research between Australian and developing country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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Preface

The ACIAR Country Profiles are designed to give a snapshot of the collaborative research being carried out between Australia and our various partner countries. This publication contains short summaries of bilateral and multilateral projects with Cambodia, Laos and Thailand that were active between 1 July 2004 and 30 June 2005. At that time there were 26 active bilateral projects and 3 active multilateral projects, the latter being led by an international agricultural research centre. There were another 13 bilateral projects under development, many of which are expected to start in 2005–06 financial year.

This publication also sets out the key outputs and outcomes from 3 bilateral projects that have been completed between at 30 June 2005.

In addition to these project summaries, the publication includes an extract from ACIAR's 2004-05 Annual Report covering Cambodia, Laos and Thailand, our near-term program as outlined in the 2005–06 Annual Operational Plan for each country, and a record of the most recent consultations held between ACIAR and Thailand on the medium-term priorities for the joint program.

ACIAR will update this profile each year and distribute them to key stakeholders in Cambodia, Laos, Thailand and Australia.

We hope you find the publication useful as a record of the progress and achievements between these Mekong partner countries and Australia. For information on ACIAR's overall program, we invite you to visit our website at www.aciar.gov.au.

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November 2005

Cambodian Report 2004–05

(extract from ACIAR Annual Report 2004–05)

Active projects in 2004–05	9
AOP budgeted expenditure in 2004–05	$1,580,000
Actual bilateral country expenditure in 2004–05	$1,200,097
Bilateral country expenditure in 2003–04	$997,832
Bilateral country expenditure in 2002–03	$721,584

Key performance indicators	Performance 2004–05
• Growth in proportion of budget for Cambodia compared with 2003–04, and involvement of new collaborating institutions	New collaborators are: Ministry of Commerce; Department of Agronomy and Agricultural Land Improvement and in Cambodian Agricultural Research Fund (CARF) projects; APHEDA, DAALI, Kompong Cham National School of Agriculture.
• Evidence of assistance in developing the capacity of the Cambodian Agricultural Research and Development Institute to carry out research on crop diversification	Several active or pipeline ACIAR projects with CARDI address legume and vegetable production, while CARDI is involved in CARF projects on maize, banana, watermelon and tomato production.
• Design and commencement of projects addressing horticulture and livestock production	Projects commenced on tomato and chilli and CARF projects on horticultural crops and cattle nutrition.
• Evidence of capacity-building in research project design and management of project leaders in Cambodian Agricultural Research Fund projects	Record number of applications received in 2004–05-round, with 20 to be funded. More than 90% of progress reports prepared with only limited help from international mentors.
• Appropriate linkages with AusAID Cambodia projects and provincial groups in extension of appropriate technologies from ACIAR projects	Strong linkages formed between the four ACIAR projects at CARDI and the AusAID-funded CARDI-Assistance Project. Two further projects working with provincial extension departments strengthened under the AusAID-funded Cambodia-Australia

Position

Cambodia is a relatively new partner country for ACIAR. It has a very low per capita GDP and the predominance of low-productivity rice-based farming systems means low levels of agricultural productivity. ACIAR now has in place a suite of projects to improve rice productivity and to begin the process of agricultural diversification. Increasing rice yields remains critical to improving food security and also incomes in Cambodia. By doing so the likelihood of farmers investing in higher-value agriculture increases. Increased rice yields per hectare will also reduce pressure to expand the area currently under cultivation to rice.

AusAID has assisted Cambodia in a number of areas and ACIAR has linked several of its projects to AusAID-supported extension. This has led to linkages with developing industries and capacity-building through training. Ensuring Cambodian researchers are brought up to date with global developments in science is a key part of project activities.

Achievements

A project to increase the productivity of rice farming in Cambodia, and also Laos, has concentrated on introducing **varieties that tolerate drought and low soil fertility** in the lowland rainfed rice systems predominant in both countries. Results from four years'

experiments at eight sites revealed the importance of sufficient water availability at plant flowering to obtain good yields. Methods of screening for drought-tolerant varieties were developed. Direct seeding and nursery technologies for use in irrigated conditions during the dry season in Laos were identified and maps of agro-ecological zones drawn. The most important result was to prove the feasibility of double cropping—the growing of two rice crops or rice and mungbean crops in rotation—each year.

Adapting successful research to control rodents is also under way. Increasing productivity by limiting losses also frees labour resources from efforts devoted to rodent control. Utilising the trap barrier system (TBS) for Cambodian conditions has moved a step closer. Scientists and extension officers have received training, and **training resources have been developed**. Significant progress has been made in demonstrating the merits of the TBS to community groups involved in the project. A key element is to clarify how sharing costs can benefit the group through increased productivity of rice.

New **opportunities for income generation** arise with increased productivity of rice. The subsistence nature of rice production has limited income resulting in limited investment into more lucrative crops, both at the farm and national scale. Now researchers are assessing the suitability of lands for non-rice cropping. District-level studies are under way in three Cambodian provinces to update soil profiles as part of a wider soil profiling initiative. More than 120 profiles are available across Cambodia, of which 61 have been developed through the ACIAR project. These are being worked into a soil map for Cambodia. Five different crop types have been sown at 20 locations across the three provinces. Capability ratings matching soils to possible crops are now in development.

Diversifying crop choice for upland areas requires an increased knowledge amongst key stakeholders, most of who have limited experience with suitable crops. **Farming households were surveyed** to gather data on upland conditions and farming systems**. Crop production issues** identified were a lack of suitable varieties (especially those with disease and pest resistance) for upland conditions. Several crops including soybean, peanut and corn have been planted in field experiments. Pests and diseases are being identified to allow resistant varieties to be sourced. The benefits of zero tillage in reducing cultivation and hence soil loss has been demonstrated; yields have equalled those achieved under conventional tillage. A new project supporting other crop diversification activities has recently begun.

Another potential market under study is aquaculture of freshwater species found in the Mekong Delta. The newly-initiated project, active in Vietnam and Cambodia, will identify the best feed and nutrition options for aquaculture diets based on local ingredients. A supporting project, active in the same two countries and Thailand, is assessing population dynamics and genetic structures of two important carp species found in the Mekong. Samples gathered are now being **subjected to genetic analysis**. This is revealing the spatial structures of populations within the Mekong, which will form the basis of sustainable stock management strategies.

Controlling fasciolosis (liver fluke) relies on accurate knowledge of the lifecycle of the fluke and **the distribution and spread of the disease**. A current project is updating risk maps and models built in past research. Extension officers are using geographic information systems to help in this process, substantially boosting their capacity in this field.

Cambodia's isolation from the world in recent decades significantly diminished scientific capacity. Rebuilding this is being undertaken through the Cambodian Agricultural Research Fund, **a component of the AusAID-funded Cambodian Agricultural Research and Development Institute Assistance Project**. The fund is helping to build a more competitive research sector through the provision of small research project grants. More than 20 grants were funded in 2004–05, with Cambodian scientists gaining opportunities for presenting and writing papers and identifying research problems available for further work. Courses for scientists other than those receiving grants have also been developed and presented.

Cambodia Plan 2005–06

(extract from ACIAR Annual Operational Plan 2005–06)

GNI per capita[1]	AUD 478
Population[2]	13.3 million
Population 2025/2050[3]	21.9 / 29.6 million
Active bilateral projects	11
Active multilateral projects	0

Bilateral actual 2003–04*	$1.0m
Bilateral forecast 2004–05*	$1.3m
Bilateral budget 2005–06*	$1.6m
Multilateral budget 2005–06	$0.0m

*Includes AusAID-funded projects: $0.15m (actual 2003–04), $0.23m (forecast 2004–05), $0.2m (budget 2005–06).

Medium-term strategy

ACIAR's strategy in Cambodia has two thrusts: firstly to support applied research that underpins agricultural diversification, particularly into non-rice crops, and secondly to support research that aims to increase the productivity of rice-based farming systems. As markets develop in Cambodia, ACIAR will place greater emphasis on research to underpin the development of suitable supply chains. Maintaining and increasing rice yields remains critical to improving food security and incomes in Cambodia. Rice security and income from rice enables farmers to invest in higher value activities such as vegetables, fisheries or livestock. Increasing rice yields can reduce the area under rice cultivation, also making more farm land available for higher value agricultural activities. The program has a strong emphasis on building Cambodian research capacity and encourages the development of collaborative linkages between Cambodian organisations.

Key performance indicators (2005–06)

- Opportunities explored to link with the new AusAID rural development program approach in Cambodia
- Better linkages established between Cambodian research and extension organisations in ACIAR projects
- Outputs of Cambodian Agricultural Research Fund projects communicated in symposia and the technical literature
- Improved description of land systems for diversification of crops from rice
- Market systems for soybeans and maize characterised and improvements suggested
- Program approach to assistance in horticulture developed
- Completion of initial aquaculture feeds trials

Position

Cambodia is a relatively new partner country for ACIAR. Australia took a major role in assisting Cambodia on its path to democracy in the early 1990s, and in doing so pledged to provide significant development assistance over the medium term. A major component of the AusAID assistance in Cambodia continues to be in agriculture and rural development. ACIAR

[1] Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2005–06*, Statement by Minister Alexander Downer, May 2005.
[2] Source: United Nations Population Division, 2004, *World Population in 2300*.
[3] Source: United Nations Population Division, 2003, *World Population Prospects: The 2002 Revision*.

will continue to take the opportunity to link several of its research projects to concluding and new AusAID-supported extension, community and market development initiatives. Activities in 2005–06 will involve a consolidation of earlier research after significant increases in the ACIAR program size over the last three years.

Cambodia has a very low per capita GDP and the predominance of rice-based farming systems on infertile soils means that Cambodia has rather low agricultural productivity on both a labour and land area basis. The suite of current, pipeline and completed projects is targeted at research to improve rice productivity, assessing land suitability for a second rice crop, and developing options for production and marketing of non-rice crops. ACIAR will continue to support selected initiatives in animal health and production as well as fisheries. There has been good progress in developing a group of Australian-trained Cambodian researchers who should be able to contribute significantly to the further development of Cambodian agriculture.

Several other donor programs in Cambodia have an agricultural and rural development focus, and where possible linkages with these programs will be established.

Indicative priorities

Priorities for ACIAR–Cambodia cooperation are established through meetings between ACIAR research program managers and executive staff and leading Cambodian agricultural R&D institutions and government bodies. The following priority areas for collaboration have been determined:

- Improving the productivity of rice-based farming systems through better agronomy and management of pests and diseases, and development of suitable rotation crops
- Technologies to support crop diversification (non-rice crops, soil management, assessment of land suitability for different crops)
- Suitable rice rotations involving legumes identified
- Market chain analysis of non-rice crops
- Improving the efficiency of production, postharvest and marketing systems for fruits and vegetables
- Improved management of animal health and production for poultry and ruminants
- Year-round availability of fish through strengthening aquaculture
- Short-course training in R&D priority-setting and management, enhancing research–extension linkages, scientific proposal and report writing in English, and in experimental design and analysis

Program adviser

Dr TK Lim

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Dr John Copland, Animal Health
Mr John Cullen, Crop Improvement and Management
Dr Ian Willett, Land and Water Resources
Dr Greg Johnson, Postharvest Technology

Country Manager

Ms Chiraporn Sunpakit, ACIAR Regional Manager, Cambodia, Laos, Thailand and Burma

Laos Report 2004–05

(extract from ACIAR Annual Report 2004–05)

Active projects in 2004–05	9
AOP budgeted expenditure in 2004–05	$910,000
Actual bilateral country expenditure in 2004–05	$824,152
Bilateral country expenditure in 2003–04	$714,519
Bilateral country expenditure in 2002–03	$545,329

Key performance indicators	Performance 2004–05
• Through consultation with Lao PDR partners and international donors, develop a new strategy for ACIAR's investment in Laos for the 2005–08 period	Lao Agriculture and Forestry researchers and CGIAR partners involved in development of medium term strategy, with priority areas identified.
• Capacity development of the National Agricultural and Forestry Extension Service (NAFES) through involvement in projects and training activities	NAFES are major partner in project and training activities associated with participatory research and extension for shifting cultivation farming systems.
• Evidence of farmer uptake of new rice varieties and fertiliser systems in central Laos	The District Agriculture and Forestry Service and World Vision Laos introduced new crop varieties and fertiliser systems to 10 villages in each of three districts in Savannakhet province.
• Better vaccine delivery systems for Classical Swine Fever for improving pig production for rural communities	The vaccine provided was ineffective in field tests; inappropriate storage was found to be the problem. Trials of new storage protocols are under way.

Position

ACIAR's program in Laos uses a small number of projects to focus on major policy and technical issues concerning shifting cultivation, livestock health, crop production and forest production. Laos has been a partner since 1992, coinciding with Australia's aid deployment in the Mekong region. Research initiatives, such as those aimed at crop and livestock farming system diversification, complement activities undertaken by donor programs of other countries. During 2004–05 ACIAR has developed a small number of projects to expand the program.

Achievements

Development of new approaches to farming in Laos is the focus of several projects. Shifting cultivation dominates upland farming systems in Laos, while in lowland areas rainfed rice cropping is the main agricultural activity. Increasing population, land degradation and resource scarcity are combining to build pressure on shifting cultivation systems. ACIAR is supporting broader initiatives to introduce sustainable changes by working with national research and extension staff. An archive about methodologies tested in Laos and elsewhere in Southeast Asia has been established out of literature searches and records of past experiences relating to upland farming. It has been used to develop case studies for use when introducing forages as the basis for improved animal production into new villages. A methodology **to encourage formation of farmer groups** has been developed to carry out this work. Involving Lao staff has substantially built local capacity in extension activities with villagers. A similar project, run through World Vision, is also delivering new technologies, this time in lowland areas. Farmers in selected central and southern districts are being schooled in planting dry-season crops, including peanuts and green beans. Although in early stages of activity some **adoption has already taken place**, with the first harvests delivering an additional income of more than US$400 per family across participating groups.

Research originally begun in Thailand to adapt low-chill temperate stone fruits suitable for local conditions is now being extended into Laos and Vietnam. Both countries have **small temperate stone fruit industries** in need of technical support. Using lessons learnt during the Thai component of the project a range of plum, peach, nectarine, pear and persimmon varieties that are better adapted to Lao and Vietnamese conditions have been introduced. Six arboreta, at two sites in Laos and four in Vietnam, have been established. Of the 1300 trees imported and planted to test their suitability to local conditions 70 per cent are still alive.

A major constraint to animal production in Laos is poor animal health caused by livestock diseases. Classical Swine Fever (CSF) and Foot and Mouth Disease (FMD) are particular problems, specifically CSF in village pig systems. A project to develop and implement **vaccination at the village level** is developing a rapid diagnostic test to support the delivery of vaccines. An ELISA test suited to local laboratory conditions has been developed and some initial testing undertaken. Evidence suggests that the CSF vaccine currently used may not be as effective as first believed. A problem relating to the transportation of currently used vaccines has been identified and is being resolved.

Farmers in upland areas have traditionally run very few cattle and buffalo. The gradual **introduction of forage species has broadened the choice** of quality feed options, leading to an increase in animal numbers. To enhance this uptake ACIAR extended a project on forages operating in China, to test lines for their suitability to Lao conditions. Trials have revealed that the acidic nature of most upland soils does not suit lucerne varieties, but that other soils found in valleys and limestone hilltops are likely to be better suited.

Forages to improve crop-livestock systems

Ban Ta village in the uplands of Laos is participating in the International Center for Tropical Agriculture Forages and Livestock Systems Project (FLSP). ACIAR has three projects that link into the FLSP, each helping introduce more sustainable farming systems.

For farmers like Pa Heu the changes have been simple but highly effective. By planting suitable forage species around her fish pond, where the plants benefit from good soil moisture, year-round growth is possible.

The forages are then hand-fed to the single buffalo Pa Heu owns. Such is the rate of the animal's growth when fed quality forages that it will soon be sold, with the profit likely to be more than US$50. Some of this money will go to purchasing a cheaper, malnourished animal. This too will then be hand-fed and fattened for sale.

One of the success factors in this approach is its simplicity. Rather than changing existing systems at a number of levels, or completely, the FLSP introduces adaptations that can deliver positive results.

Traditionally livestock were left to graze in nearby jungles and were at the mercy of predators—both animal and human. Now these animals are kept closer to villages and are fed a diet superior to that available through wild-grazing. The benefits are not just to buffalo—pigs fed sweet potato and legumes as part of their diets are also exhibiting improved health and growth.

For Ban Ta's farmers, and others in villages participating in the FLSP, these changes have helped them take the step from subsistence farming to income generation.

The suitability of plant species to alleviate saline soils is the subject of another project, operating in Thailand but with some activities in Laos. Dryland salinity has the potential to become a problem in Laos. Modelling groundwater movements and interactions with saline areas in the Champhone catchment is now complete. Now researchers are determining appropriate management approaches, such as planting **saline-tolerant tree, shrub and grass species**. Salinity risk areas are being mapped and monitored, with the research also having significant applications in Thailand and Australia.

Laos Plan 2005–06

(extract from ACIAR Annual Operational Plan 2005–06)

GNI per capita[4]	AUD 493
Population[5]	5.3 million
Population 2025/2050[6]	8.6 / 11.5 million
Active bilateral projects	8
Active multilateral projects	0

Bilateral actual 2003–04	$0.7m
Bilateral forecast 2004–05	$0.8m
Bilateral budget 2005–06	$0.8m
Multilateral budget 2005–06	$0.1m

Medium-term strategy

ACIAR has a moderate sized (but growing) program in Laos which focuses on major technical issues addressing alternatives to shifting cultivation in the uplands through better crop and forest production and livestock health and production. The diversification of rice-based farming systems in both lowland and upland areas into other cropping, livestock and fisheries enterprises is receiving increasing attention. Research interventions are often designed to complement major donor programs on improving rice production (IRRI–Swiss), forages (CIAT), forestry (Germany; Sweden), irrigation (Asian Development Bank, Denmark, UNDCF) and animal health (European Union).

Key performance indicators (2005–06)

- Through consultation with Lao PDR partners and international donors, continue to develop a new strategy for ACIAR's investment in Laos for the 2005–2008 period
- Better identification of research and extension interventions which may help to reduce the extent and impacts of shifting cultivation
- Scaling out of low-chill fruit production to community groups
- Increased recognition by local and national governments of the salinity hazards of irrigation expansion and catchment clearance
- Design of new forestry projects targeting improvements in smallholder timber and non-timber forest product production

Position

ACIAR has had a program in Laos since 1992, coinciding with the period of expansion of Australia's aid program to the Mekong countries. Distinguishing features of this landlocked country are low population density, high ethnic diversity, poor infrastructure, and geographical dispersion of people. Agriculture employs over 80% of the population and forms 53% of GDP. Major agricultural exports include timber and wood products and coffee.

A major emphasis has been the establishment in Vientiane of an animal diseases laboratory to service Laos. Other successes include the introduction and selection of cold- and drought-tolerant rice varieties, identification of the major rodent pests affecting rice farming, capacity building in forestry research and agricultural extension approaches, management of

[4] Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2005–06*, Statement by Minister Alexander Downer, May 2005.
[5] Source: United Nations Population Division, 2004, *World Population to 2300*.
[6] Source: United Nations Population Division, 2003, *World Population Prospects: The 2002 Revision*.

indigenous fisheries, and provision of training, including in scientific data analysis and scientific writing in English.

During 2005–06, ACIAR intends to expand the Laos program where opportunities for research collaboration with a high likelihood of farmer impact exist.

Indicative priorities

Priorities are determined through discussions, interactions and visits between scientists and research managers from Lao PDR, ACIAR and Australian institutions.

Future collaborations will continue to encourage linkages with other donor-funded programs and aim to extend the impact of previous ACIAR-funded projects in the region. Research and development will be focused on:

- Technical and policy interventions in upland areas, to improve the profitability of low-input farming as an alternative to shifting cultivation
- Improved productivity of the dominant rice-based farming systems and diversification to include other field and horticultural crops, livestock and fishery enterprises
- Animal health and quarantine, especially related to the critical geographic location of Laos as a livestock transit point
- Reforestation and sustainable smallholder forestry, including through use of improved germplasm, and enhanced silvicultural management
- Analysis of off-site impacts of irrigation in lowland areas to influence appropriate establishment of systems
- Smallholder riverine fisheries and pond aquaculture
- Enhancing the impact of earlier ACIAR project investments at the farmer level

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Mr John Cullen, Crop Improvement and Management
Dr Russell Haines, Forestry
Dr Ian Willett, Land and Water Resources

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Thailand Report 2004–05

(extract from ACIAR Annual Report 2004–05)

Active projects in 2004–05	16
AOP budgeted expenditure in 2004–05	$570,000
Actual bilateral country expenditure in 2004–05	$522,291
Bilateral country expenditure in 2003–04	$1,102,630
Bilateral country expenditure in 2002–03	$1,090,643

Key performance indicators	Performance 2004–05
• All new projects under development are focusing on implementation of results of earlier ACIAR projects	All three projects under development emphasise results of earlier projects on livestock breeding strategies, shrimp health and domesticating high-value trees.
• Evidence of increased farmer involvement in projects on soil fertility management, crop production and fisheries	Scale out of two World Vision–ACIAR collaborative projects on vegetable production and aquaculture beyond original provinces and districts; involvement of farmer groups near Khon Kaen in project on alleviation of acidity from legume production on acid soils.
• Linkages through collaboration and training of Thai scientists to counterparts in neighbouring countries in at least three projects	Collaboration with Lao and Cambodian scientists in Mekong fish stock mapping; with Indonesian scientists on shrimp diseases and on water yield and quality in agroforestry systems; with Lao and Vietnamese counterparts on low-chill fruit production; with Malaysian, Philippines and Vietnamese scientists on fruit germplasm conservation.
• Effectiveness of on-farm shrimp disease control and management programs validated and extension through farmer networks initiated	Disease control programs validated on-farm, Thai language extension materials produced and widely disseminated to farmer groups and government extension centres.
• Enhanced Thai capacity in sanitary and phytosanitary policy issues	Capacity developed to enable use of WTO-compatible mechanisms for monitoring food safety standards, particularly in fisheries and processed vegetable products.

Position

Thailand was an original ACIAR project partner and has been involved in more than 100 successful projects since 1983. In recent years growth in the Thai economy, and with it research capacity, has seen a shift in the focus of project activities. The emphasis now is on seeking greater implementation of the results of past projects, both within and outside Thailand, by smallholder farmers. A secondary focus is on the management of natural resources, particularly in north and northeast Thailand.

New activities in Thailand bring the results of research to smallholders. How to harness Thai research capacity to assist neighbouring countries is considered in project design. This includes recent policy and technical projects relating to trade issues such as sanitary and phytosanitary regulations and the impacts of trade reform and liberalisation on the Thai economy. Several projects involving Thai institutions are reported under other countries.

Achievements
World Vision–ACIAR partnership with has worked to disseminate research results in Laos, Vietnam and Thailand. In Thailand's Songkla Basin vegetable farmers have **adopted new management methods** that significantly reduce chemical runoff. Past research had identified chemical applications as the cause of water contamination. By replacing chemicals with diluted chicken manure and introducing other management improvements farmers have grown quality crops that are marketed as being pesticide-free. This attracts a price premium. A second Thai component has introduced low-cost feeds based on locally available ingredients to aquaculture farmers in Udon Thani and Surin provinces. Farmers learnt the technology to prepare feeds at a community centre and the Thai Department of Agriculture provided follow-up technical support. By replacing commercial feeds with locally produced ingredients profit margins have increased. As a result of seeing this success more than 600 farmers have now established aquaculture ponds.

The final Thai component has extended the introduction of low-chill stone fruit species to northern highland areas. More than 18,000 seedlings distributed as part of the World Vision project to 1000 farmers have been planted. Current activities focus on **improved technology for growing healthy trees** and examining intercropping options to generate income until the trees mature.

Crop losses caused by metal contamination in peri-urban areas are common in parts of Thailand and elsewhere in Asia. Rice, potato and peanut, along with other crops, are often rejected at market by buyers who suspect possible contamination. Thai scientists are involved with Vietnamese counterparts in an ACIAR project addressing this issue. The **collaborative approach is developing improved soil data** collection and assessment techniques. Geographic information systems were used to map heavy metals in crop lands in both countries, and the scientists now know the level of background metals found in soils. Tests of ecotoxicity, to assess environmental effects from metals, have been refined and improved.

Improving the quality of shrimp produced through aquaculture is the subject of another ACIAR project, operating in Thailand and Indonesia. The project has validated farm-level controls for diseases of shrimp and extended these and past research findings to farmers for field trials, achieving **a greater than 70 per cent success rate** in ensuring good harvests.

Managing soil salinity and acidification has been addressed in two projects now concluding. Regional **modelling of land and water use in saline areas** of Thailand's northeast has demonstrated current practices do not maximise environmental benefits or economic returns. This information is now being directed to policy makers. A second project, working also in China, has tested legume-based production systems in acidic soils. Methods of alleviating acidification have been developed and include addressing nitrogen depletion.

Other research issues relate to trade globalisation and development and their impacts at the macro and micro levels. An examination of agribusinesses involved in commodity exports to **determine the impact of sanitary and phytosanitary trade regulations** are under way. A number of issues relating to the acceptance or refusal of food exports by potential buyers and the implications of these for domestic industries have been assessed. Case studies examining these implications in individual agribusiness firms have been developed. This information is now being disseminated to researchers and policy makers in India and Thailand. At the farm level the impact of men working off-farm or migrating to urban areas in search of work has resulted in lost productivity. The project is examining strategies and options to deliver appropriate technologies for women left to run farms.

Thailand Plan 2005–06

(extract from ACIAR Annual Operational Plan 2005–06)

GNI per capita[7]	AUD 3,376
Population[8]	60.9 million
Population 2025/2050[9]	73.9 / 77.1 million
Active bilateral projects	7
Active multilateral projects	3

Bilateral actual 2003–04	$1.1m
Bilateral forecast 2004–05	$0.6m
Bilateral budget 2005–06	$0.4m
Multilateral budget 2005–06	$0.2m

Medium-term strategy

ACIAR's Thailand program seeks greater implementation of the results of earlier projects (often in conjunction with NGOs) to ultimately benefit very poor farming communities. A second focus involves management of natural resources, especially in North and Northeast Thailand (including degradation by acidity and salinity as well as water resource management). In keeping with the graduation of Thailand as a recipient of aid to one of emerging donor, only a very limited number of new and small co-funded activities, all of which will focus on implementation of the results of earlier ACIAR projects, will be considered in future. Opportunities for partnering with Thailand on activities in the region will also be explored.

Key performance indicators (2005–06)

- Improved implementation and measurement of results of earlier ACIAR projects
- NGOs building on ACIAR-funded pilot projects using their own resources
- Evidence of increased farmer involvement in projects on soil fertility management, crop production and fisheries
- Policy briefs on technical changes resulting from research interventions used for planning by Thai research managers
- Acceptance by government departments for pollution control of recommendations on maximum concentrations of key heavy metals in soils and crops

Position

Thailand was an early and large collaborator, with many projects successfully undertaken. However, as Thailand's own economic and research capacity has increased, its involvement in ACIAR projects has diminished. Successful outcomes include techniques to ensure longer shelf life that have enabled the expansion of tropical fruit exports, the development of cooler climate fruits for the hilly regions of northern Thailand, and fruit fly identification and control. New fish feed made from cheap, locally available ingredients has helped thousands of Thai fish farmers. A substantial investment in diagnosis and control of foot-and-mouth disease has made Thailand the accepted regional centre of expertise in Southeast Asia. The use of software (developed under ACIAR support) to assist in selection in cattle breeding programs

[7] Source: Commonwealth of Australia, *Australia's Overseas Aid Program 2005–06*, Statement by Minister Alexander Downer, May 2005.
[8] Source: United Nations Population Division, 2004, *World Population to 2300*.
[9] Source: United Nations Population Division, 2003, *World Population Prospects: The 2002 Revision*.

has been recognised through national awards. Over 10,000 hectares of suitable fast-growing Australian trees are planted each year as a result of ACIAR-funded research.

It is expected that Australian investment in projects will continue to decrease in line with the increasing ability of Thai partners to co-invest in projects of strong mutual importance. In some cases, there are spillovers to less developed countries from drawing on the development experiences of Thailand. ACIAR's project investment will be very highly selective and will focus only on implementation of the results of earlier ACIAR projects.

Indicative priorities

ACIAR held its most recent consultation to establish priorities for research collaboration with Thailand in November 2000. The full record of the consultation is at www.aciar.gov.au under Partner country priorities/Thailand. At that consultation the themes of application of biotechnology, product quality and quality control, natural resources management, and information dissemination and technology transfer were given priority, and the current portfolio of projects that are being completed largely reflects this emphasis.

Overarching issues include the potential benefits from technical and policy research to underpin trade of agricultural products, and the importance of policy research and market chain incentives in underpinning agricultural developments. Opportunities to promote the application of technology, using both conventional extension methodologies and new approaches were noted, especially for the benefit of farmers in upland northern Thailand and Northeast Thailand.

Key program managers

Dr Ray Trewin, Agricultural Development Policy
Dr John Copland, Animal Health
Dr Ian Willett, Land and Water Resources

Country Manager

Ms Chiraporn Sunpakit, ACIAR Regional Manager, Cambodia, Laos, Thailand and Burma

Active projects

at 30 June 2005

Bilateral

Bilateral

Project ADP/2000/004: International food safety regulation and processed food exports from developing countries: A comparative study of India and Thailand

Overseas Collaborating Countries	India, Thailand
Commissioned Organisation	Australian National University, Australia
Project Leader	Professor Prema-Chandra Athukorala Phone: 02 6125 8259 Fax: 02 6125 3700 Email: prema-chandra.athukorala@anu.edu.au
Project Web Site	http://rspas.anu.edu.au/economics/aciar/
Collaborating Institutions	Research Information Systems for the Non-aligned and Other Developing Countries, India University of Melbourne, Australia International Food Policy Research Institute, USA Thammasat University, Thailand
Project Budget	$546,150
Project Duration	01/01/2002 to 31/12/2005 (Project extended from 01/01/2005 to 31/12/2005)
ACIAR Research Program Manager	Dr Ray Trewin

Project background and objectives

India and Thailand, like a number of other agricultural resource rich developing nations, have experienced significant expansion of processed food exports. In recent years Thailand has exported over US$10 billion worth of processed food (4 per cent of GDP) and India over US$3 billion worth (2 per cent of GDP). However, both India and Thailand, and other developing countries, have experienced significant problems in exporting processed food to lucrative markets in developed countries. These trade conflicts often relate to food safety standards and their inability to meet the WTO Sanitary and Phytosanitary (SPS) Agreement. For example in 1999-2000 there were 860 shipments of fishery, vegetables and fruit products from India placed in detention in the US and 684 cases of products from Thailand.

SPS issues have become a significant source of international trade friction and dispute. While the development of food processing export industries offers enormous potential for rural development and economic growth in developing countries, problems with meeting these standards are considered a major constraint to achieving this growth. There is a lack of adequate information on the problems that constrain firms' ability to meet international standards. This study aims to examine the policy, institutional and technical problems faced by processed food exporters in developing countries in meeting SPS requirements, and to identify appropriate policy measures minimise their negative impacts on exports and enhance their capacity to meet SPS standards while recognising the legitimate concerns in importing countries about safety and quality.

Project progress

Year 3 (01/01/2004-31/12/2004)

The main tasks accomplished so far included: a literature survey, and an analysis of trends and patterns of process food exports from developing countries and the WTO mechanism for monitoring food safety standards. Institutional mechanisms and procedures for meeting food safety standards in India and Thailand, along with case studies of the selected food industries and firm-level surveys in the two countries are underway, as are preliminary drafts of the country reports.

The main focus of the Indian and Thai research teams was on analysing data gathered from the firm-level survey and drafting the country reports. The team leader and the main co-researcher of each team visited ANU during the year to discuss the preliminary draft of the report with the Australian team and the complete draft is to be submitted by the first week of June 2005. The Indian team has surveyed 71 firms. These include firms in the following industries: shrimp (57) mango pulp (7), egg powder (3) and mushroom (4) industries in the states of Kerala, Tamil Nadu, Andra Pradesh, Chandigar and Maharashtra. The Thai team has surveyed 55 firms – Shrimp (40), canned tuna (8) and vegetable (7).

The Australian team was involved in writing/finalising the background chapter for the synthesis volume, which contains three main sections: international food safety regulation and process food exports from developing countries, causes and incidence of detention of processed food imports (based on data compiled from administrative records of the US Food and Drugs Administration), and the economics of food safety regulation and trade.

Project ADP/2002/012: Technical change in Thai and Indonesian agriculture: measurement, socio-economic impact and policy implications

Overseas Collaborating Countries	Indonesia, Thailand
Commissioned Organisation	Australian National University, Research School of Pacific and Asian Studies, Australia
Project Leader	Professor Peter Warr Phone: 02 6125 2682 Fax: 02 6125 3700 Email: peter.warr@anu.edu.au
Collaborating Institutions	National Center for Genetic Engineering and Biotechnology, Thailand Chulalongkorn University, Thailand Bogor Agricultural University, Indonesia Centre for Agro-Socio Economic Research and Development, Indonesia
Project Budget	$399,799
Project Duration	01/01/2004 to 31/12/2006
ACIAR Research Program Manager	Dr Ray Trewin

Project background and objectives

This project aims to identify agricultural industries that have shown productivity growth and determine why they have grown — is it biotechnical change such as improved crop varieties and cultivation methods, mechanisation, management improvements, or other reasons? Researchers will examine the economic and social effects of this technological change, including effects on agricultural trade, income distribution and poverty. They will assemble a large data set encompassing eight major agricultural sectors and undertake a statistical analysis of the rate and factor-saving biases of technical progress in each sector.

Project progress

Year 1 (01/01/2004-31/12/2004)

An Inception Workshop was held in Thailand, near Bangkok, in August 2004. At this workshop the objectives, methodology and operational details of the project were discussed and agreed upon. The Indonesian team gave a presentation on Indonesian agriculture, including preliminary modelling results on the effects of technical change in Indonesian agriculture. Discussion then focused on the steps needed to develop the quality and usefulness of these exercises within the work of the project.

The Australian team focused on working with the Thai and Indonesian teams to develop the data on agricultural inputs and outputs which will be used for statistical analysis of the nature of technical change. Progress was made in CGE modelling, especially in the case of Indonesia. The existing Wayang CGE model of the Indonesian economy was updated to 2000 data and applied to the analysis of rice import quotas and import tariffs. A substantial paper on this subject was completed. The database for this work was assembled by the Indonesian team.

The Thai team worked on two fronts. The team at BIOTEC focussed on acquisition of CGE modelling skills. This was to be supplemented in February 2005 by the participation of Mr Thepnarong Noppagornvisate of BIOTEC in a GEMPACK training course at Monash University in Melbourne. This will increase the number of GEMPACK users at BIOTEC from 1 to 2, with a third person to be trained at a later date.

The Chulalongkorn University team focussed on construction of an updated database for the PARA CGE model of the Thai economy. This data base is expected to be completed in early

2005. In November 2004 the BIOTEC team joined the Chulalongkorn team in this database assembly task.

The Indonesia team made substantial progress with assembly of the data set on agricultural inputs and outputs which will be used for statistical analysis of the nature of technical change. Progress was also made on CGE modelling of issues related to technical change and a paper on this subject was completed.

Project AH/2003/001: Management of CSF and FMD at the village level in Lao PDR

Overseas Collaborating Countries	Laos
Commissioned Organisation	CSIRO Livestock Industries, Australian Animal Health Laboratory, Australia
Project Leader	Dr Laurence Gleeson Phone: (03) 5227-5038 Fax: (03) 5227-5555 Email: Laurence.Gleeson@csiro.au
Collaborating Institutions	University of Melbourne, Faculty of Veterinary Science, Australia International Centre for Tropical Agriculture, (CIAT), Laos Department of Livestock and Fisheries, National Animal Health Centre, Laos
Project Budget	$399,329
Project Duration	01/07/2003 to 30/06/2006
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

Smallholder farmers in Laos view livestock production as a means to generating cash income. With more than 85 per cent of the country's population located in rural areas sales of livestock are vital to poverty alleviation. Almost all livestock is raised by smallholders, with pigs the most common in smallholder and village systems. Livestock production and accessing cash from sales are a 'stepping stone' away from poverty, but are limited by the persistent outbreaks of some diseases. Losses due to disease are a major constraint particularly in pig and poultry systems. Earlier ACIAR-supported research identified Classical Swine Fever (CSF) as the major cause of death in village and smallholder pig systems. Anecdotal evidence supports this finding, suggesting epidemics occurring in some regions on a two to three year cycle. Foot and mouth disease (FMD) is another common disease, though is not endemic in some parts of the country as CSF.

Control of both diseases is a national priority, but is limited by significant knowledge gaps for each. For FMD this centres on disease surveillance activities, which will also deliver benefits in improving skills and methodology for managing other diseases. For CSF a live virus does exist, but maintaining its efficacy has been difficult. A more stable vaccine, improved vaccine management and simple diagnostic tests are needed to rebuild farmer confidence in the effectiveness of vaccinations. The project aims to improve the control of CSF and FMD in village pigs through:

- development, evaluation and implementation of a simple, rapid diagnostic test for CSF,
- establishment and validation of a system to apply locally produced CSF vaccine,
- evaluation of the impact of the CSF vaccine program in the village pig production system,
- monitoring the epidemiology of FMD and CSF, and
- communication of project findings to extension staff and animal health and production scientists in national, regional and international networks.

Project progress

Year 2 (01/07/2004-30/06/2005)

A simple, rapid diagnostic test for CSF The test format was modified to a read-out using ELISA generated colour development and has been termed an immuno-magnetic bead (IMB) ELISA. The binding conditions of the reagents and the conditions for the performance of the IMB test have been standardised. Proof of principle of the IMB test format has been

established. The IMB ELISA can be successfully transferred to the National Animal Health Centre's central laboratory environment in Lao PDR.

Establishment & validation of a system to apply locally produced CSF vaccine There has been concern about commencing the vaccination program in the villages prior to the reliability of the vaccine being established. The established antibody detection ELISA indicated that in many vaccinated pigs there was no humoral antibody response. Some activity was redirected to the evaluation of the vaccine by use of the virus neutralisation test that showed that the vaccine was stimulating an antibody response in some pigs. A decision was made to boost the initial vaccination in villagers with a second vaccine a month later.

The current recommended temperature for the storage of CSF vaccine produced at the National Vaccine Production Plant is -20^{o}C. Most provincial animal health offices do not have proper equipment to hold the vaccine at this temperature. Because commercially available live CSF vaccine can be stored for up to 12 months at -20^{o}C, a trial was carried out to compare the potency of the vaccine (as measure by antibody response) after longitudinal storage of the vaccine at 4^{o}C and at -20^{o}C. This assessment indicated that the vaccine is not stable at 4^{o}C, but maintains potency for up to 4 months at -20^{o}C as specified by the manufacturer. The local project leader organised and delivered the vaccination program in an additional 8 village in Borikhamxay province and in FLSP villages in 2 districts in Xiengkhouang province.

Evaluation of the impact of the CSF vaccine program Sera have been collected from a sample of pigs vaccinated in the village program but the testing is not yet complete. Production data has been collected from the project villages during the vaccination trial. The project will undertake an evaluation of the villagers' attitude to the impact of the vaccination program as implemented by the project, to evaluate and attempt to provide some information to influence policy about CSF vaccine production.

Monitoring the epidemiology of FMD and CSF Monthly production data from the villages enrolled in the project continues to be collected. There have been no outbreaks of CSF reported from the project villages. The project has been collaborating with the SEAFMD campaign by undertaking FMD serological surveys in three provinces. Limited results indicate that FMD is not endemic in Savannakhet, Xiengkhouang and Houaphan. There was one type O outbreak reported in the year, and a follow up investigation will be undertaken by the project to determine the origin.

Communication of project findings The findings of the FMD studies and activities undertaken in the project were communicated to the Annual meeting of the SEAFMD program.

Project AH/2002/099: Development of a model for the control of fasciolosis in cattle and buffaloes in the Kingdom of Cambodia

Overseas Collaborating Countries	Cambodia
Commissioned Organisation	James Cook University, School of Biomedical Sciences, Australia
Project Leader	Dr Lee Skerratt Phone: 07 4781 4838 Fax: 07 4779 1526 Email: Lee.Skerratt@jcu.edu.au
Collaborating Institutions	Department of Animal Health and Production, Cambodia Cambodia Agricultural Research and Development Institute, Cambodia Agricultural Extension Department, Cambodia Office of Animal Health and Production, Cambodia
Project Budget	$149,554
Project Duration	01/01/2004 to 30/06/2006 (Project extended from 01/01/2006 to 30/06/2006)
ACIAR Research Program Manager	Dr Peter Rolfe

Project background and objectives

Control of fasciolosis (liver fluke) is a high priority in Cambodia. A previous ACIAR project (AS1/1996/160) gathered data on the spread of fasciolosis to produce a risk map, but much of this was out of date. The lack of accurate data also precluded the model from playing a major role in developing a national control strategy. Recent data collection by several national and regional agencies will allow the model to be updated. The project aims to update, refine and validate the risk model using geographic information systems. Extension officers will be trained with the aim of developing an extension program to control fasciolosis, leading to the development and promotion of a national strategy.

Project progress

Year 1 (01/01/2004-31/12/2004)

The project has two components:

- implementation and evaluation of an extension program for fasciolosis
- refinement and validation of a GIS-based risk model for fasciolosis in Cambodia.

The study was conducted in two provinces; in Kandal on implementation and evaluation of an extension program for fasciolosis and in five districts of Kampong Cham on the refinement and validation of a GIS-based risk model for fasciolosis.

Implementation and evaluation of an extension program for fasciolosis: The extension officers from the Department of Animal Health and Production (DAHP) and the Office of Animal Health and Production (OAHP) extension office, Saang district, Kandal province, participated in the extension training workshop organized by the Cambodian Agriculture Research Development Institute (CARDI) and the Agricultural Extension Department (AED) in July 2004 at CARDI. The instructors and experienced officers of CARDI and AED prepared the training program.

A revised draft of the 25-page Khmer language training manual entitled *Training manual for extension trainer on extension lessons and methods for the control and eradication of fasciolosis in cattle in Saang district, Kandal province* was produced. The DAHP, AED, OAHP extension team and extension officers in Saang district discussed and developed extension materials to support the extension work on control of fasciolosis. Extension materials were approved by the DAHP before use.

Fasciolosis impacts, cost benefits of fasciolosis control and acceptance of control measures Cattle of different age groups on two project sites were selected for the study on fasciolosis prevalence, weight gain, condition rating, skin status, draught ability, animal sale and reproduction performance. This information was recorded every four months from September-October 2004. The two project sites which have a similar farming system, grazing management and feeding approach, were selected for the study. Project Site I at Preak Thei was used as a control group. Project Site II at Preak Kseav and Preak Trang was used as a non-control group. For the study, cattle were classified into different age groups: 0-1 year old, 1-2 years old, 2-3 years old, 3-4 years old, 4-5 years old and older than 5 years. Fasciolosis infection rate (faecal collection and analysis), weight, condition rating, skin status, draught ability, animal sale and reproductive performance were all recorded.

For the Control group at Preak Thei animals were identified by a neck tag, vaccinated against haemorrhagic septicaemia (HS), foot and mouth disease (FMD) and given an anthelmintic for nematodes. Any calves were given an anthelmintic for *Toxocara*. At Preak Kseav and Preak Trang an extension activity for control of fasciolosis was conducted. Animals were selected, identified by a neck tag, vaccinated against HS, FMD, and were given triclabendazole against fasciolosis and an anthelmintic for nematodes. Any calves were given an anthelmintic for *Toxocara*.

A total of 848 faecal samples from the control and non-control groups were examined in September-October 2004 to determine the fasciolosis infection rate. In the control group, the infection rate of fasciolosis was 39 percent. In the non-control group, the infection rate of fasciolosis at the start was 43.42 percent. A total of 114 cows in the control and non-control groups aged older than 18 months were included in the study of reproductive performance.

Extension program to control fasciolosis in cattle in Saang and evaluation of acceptance of the control program Extension activities were implemented by the Kandal province DAHP, OAHP extension team under the supervision of extension specialists from CARDI, AED and the Cambodian Australian Agricultural Extension Project.

A total of 90 families (39 per cent) out of 230 families on the two project sites participated in the survey. Of these, 30 per cent were from Project Site I (Preak Thei) and 43 percent were from Project Site II (Preak Kseav and Preak Trang). Most of the farmers did not have any knowledge of fasciolosis, disease impacts and prevention. They remarked that animals were skinny, suffered from diarrhoea and low fertility, with the price of live animals lower than in other places. Farmers who had cattle on the project location were invited to participate in the extension session (open-air school). Each session was conducted for two days. A total of 142 people (93 percent) on Project Site II participated in the program.

Refinement and validation of a GIS-based risk model for fasciolosis in Cambodia A total of 1,132 faecal samples were collected from five districts in Kampong Cham province, which included 311 samples from high-risk areas, 301 samples from moderate-risk areas, 262 samples from low-risk areas and 262 samples from no-risk areas. A census of cattle and buffalo in the selected districts was conducted in order to identify individual animals in these areas, and make a selection of some of them. The faecal examinations showed that 139 out of the 1,132 samples collected tested positive for *Fasciola* eggs. The highest prevalence of fasciolosis was found in Batheay district — 24 per cent, followed by Prey Chhor — 11 per cent, Chamcar Leu and Orang Ov districts — 6 per cent, and Stoeung Trang - 3 per cent.

The levels of prevalence of fasciolosis found in the field survey generally matched predictions from the risk model, except in Stoeung Trang where the prevalence was higher. This mismatch between the GIS model and field survey results may be due to the distribution of animals and the fact that the use of the land within districts is unlikely to be uniform (some animals may be allowed to graze in areas where the risk of fasciolosis is high), as is implied by the model. However, the general agreement of the risk model with predicted prevalence in most districts surveyed suggests that the epidemiological determinants and weightings used to produce the model are appropriate.

Project ASEM/2001/107: Accelerating the impacts of participatory research and extension on shifting cultivation farming systems in Laos

Overseas Collaborating Countries	Laos
Commissioned Organisation	Charles Sturt University, Natural Resource Management and Extension, Australia
Project Leader	Dr Joanne Millar Phone: 02 6051 9859 Fax: 02 6051 9897 Email: jmillar@csu.edu.au
Collaborating Institutions	National Agriculture and Forestry Extension Service, Department of Livestock and Fisheries, Laos International Centre for Tropical Agriculture, (CIAT), Laos
Project Budget	$394,476
Project Duration	01/07/2003 to 31/12/2005
ACIAR Research Program Manager	Dr Ken Menz

Project background and objectives

Upland areas of northern Lao PDR have not benefited from market intensification and diversification in agriculture taking place along the country's Mekong corridor. The majority of the population in these areas live in rural households and villages and are engaged in shifting agricultural cultivation. The poverty gap between those rural householders in the Mekong corridor and those in the upland areas is widening, with upland minorities in danger of being left behind. Poverty in upland areas has increased through a combination of factors, including population increases, poor land allocation policies, resettlement and natural disasters. Crop rotations have shortened and yields have fallen, livestock diseases, pests and weeds are present and upland rice dominates cropping systems. The national average area for rice production is only 31 per cent, but in the northern uplands it is more than 65 per cent. Householders rely on livestock and fish rearing to generate cash income.

Farming systems vary greatly, within and between villages depending on land tenure and access, soil types and fertility, labour, forest resources, market access, diseases and farming and traditional skills. Creating the means by which farmers become willing to transition to more sustainable agricultural systems is linked to knowledge of the practices to support these systems. Working with farmers in participatory research is an effective way to transfer knowledge and begin transition, as well as offering insights into why farmers make choices to change or remain with traditional approaches. The overall aim of the project is to determine effective ways to accelerate and spread the impacts of participatory research and farmer innovation as implemented by the FLSP towards more economically and biologically sustainable upland farming systems, through:

- understanding how and why farmers are able to modify their upland farming systems away from a reliance on shifting cultivation through the use and innovation of relevant technologies,
- accelerating and spread impacts resulting from participatory research and extension, and
- facilitating organisational learning and development towards participatory approaches.

Project progress

Year 2 (01/07/2004-30/06/2005)

Why some farmers modify their upland farming systems A major village survey (30 villages) was conducted in Xieng Ngeun district, Luang Prabang province in 2005 to determine the factors enabling, driving or limiting farming systems change. Major village and institutional factors include remoteness, distance from markets, land allocation, relocation, limited water

supply, and lack of technical or market information. Farmers are interested in moving away from shifting cultivation if they can generate enough cash income from cash crops, livestock, forest products and handicrafts. However rice security is paramount to their concerns along with uncertainty over new crops and markets, livestock diseases and diminishing forest resources. Households are seeking reliable technical and market advice as well as credit schemes to enable them to trial new enterprises while minimising risk to their livelihoods.

Thirty two case studies have been developed to document production and livelihood benefits from using forages for livestock. Men and women farmers from four different ethnic groups and five districts explained how they addressed immediate problems by growing and feeding forages to livestock (cattle, buffalo, goats, pigs, poultry and fish). Initial benefits were faster livestock weight gain, healthier animals, reduced labour in finding local feed, closer management of livestock, reduced cost of buying pig feeds, and better prices for fattened animals. Over time these benefits impact on livelihoods and poverty reduction such as children being able to go to school, increased cash income to buy goods, and more time to diversify into other enterprises. For some families, their reliance on upland rice production and shifting cultivation has been reduced or removed. However, moving away from traditional upland rice production is a long term process and may be more difficult for poorer or disadvantaged households to achieve if land, labour and credit are not readily available.

Another study has been conducted to further understand the complexity of household livelihoods and decision making by also interviewing farmers who have stopped using forages and farmers who have not adopted forages. Preliminary results show that some farmers are constrained by their age, limited land and labour, lack of cash to buy livestock or fencing, preference for growing crops or negative experiences with growing forages. In some cases, farmers simply were not aware of forages or their potential.

Accelerating and spreading the impacts of participatory research Three participatory extension methods were trialled to introduce potential impacts to 53 new FLSP villages in 2004. They included case study photos and system sketches; cross visits to village with impacts and champion farmer visits. Interviews were conducted with farmers and district staff several months after the methods were used to determine how effective each method had been in stimulating farmer learning, adoption and impacts. Cross visits were found to be more effective in creating informed awareness and confidence in using forages than case study presentations or champion farmer visits. Cross visits were also the preferred learning method for most of the farmers interviewed. Farmers were able to see the technology being used, interact with host farmers and immediately apply what they had learnt.

Farmers also expressed the need for more technical and practical information to accompany or follow case studies. Champion farmers visits are the preferred learning method for some farmers who do not want to travel or learn in groups. District staff were able to identify the advantages and limitations of each extension method as well as factors that influence farmer willingness and capacity to engage in and benefit from a new technology. As a result, staff are now able to develop extension plans for villages using their preferred mix of extension methods based on their knowledge of the farmers and their stage in learning.

Facilitate and understand organisational learning for participatory research and extension Interviews were conducted with 14 district and extension staff during October 2005 to explore how they work with farmers and their views on different extension methods. All extension staff use a combination of group and one to one extension, and were adamant that both methods were needed. Most staff observed that having a farmer group leader in the village helped to stimulate farmer involvement and organisation of activities. Pre-season and mid-season workshops involving all district and provincial staff allow valuable review and reflection on field activities, extent of impacts and development of extension plans and strategies.

Project ASEM/2000/109: Farming systems research for crop diversification in Cambodia and Australia

Overseas Collaborating Countries	Cambodia
Commissioned Organisation	NSW Department of Primary Industries, Australia
Project Leader	Dr Bob Martin Phone: 6763 1258 Fax: 02 6763 1222 Email: bob.martin@agric.nsw.gov.au
Collaborating Institutions	Cambodia Agricultural Research and Development Institute, Cambodia
Project Budget	$887,591
Project Duration	01/07/2003 to 30/06/2007
ACIAR Research Program Manager	Dr Ken Menz

Project background and objectives

Rice is the staple crop in Cambodia, with little else grown. More than 90 per cent of agricultural cropping land is sown to rice. Crop diversification is minimal, even in upland agro-ecological systems that do not suit rice. Government policy is designed to encourage diversification with CARDI taking a lead in placing emphasis on diversified cropping. There are, however, still substantial barriers to diversification. The main is a lack of familiarity with upland crops. This includes extension workers and researchers as well as farmers, whose knowledge of non-rice crops is limited, creating a perception of higher risk for planting non-rice crops. A wet monsoonal season does not guarantee predictable rainfall, this unpredictability adding to the perception of risk. As a result market infrastructure for non-rice crops is lacking.

Crop diversification is also an issue at the centre of a policy push from NSW Agriculture, who want to hasten change from cereal crops production, in parts of the state. The adoption of more sustainable tillage practices is a central theme of this push.

The overall objective is to help reduce poverty and contribute to food security at household and national levels through the development of techniques and opportunities for the production of non-rice upland crops in Cambodia. In Australia the focus is on overcoming the constraints to crop diversification and adoption of sustainable practice in broad acre cropping enterprises in the sub-tropical slopes and plains agro-ecological region of northern Australia.

Project progress

Year 2 (01/07/2004-30/06/2005)

During 2004-05, farmer workshops were conducted in Battambang and Kampong Cham, Cambodia, to document farmers' knowledge of and problems with growing upland crops. A series of workshops were held covering; the broader issues and problems growing upland crops, more specific questions about the crops to be grown in 2005, such as the area sown, why the crop was chosen, seeding rates, row spacing, fertiliser and pesticide use, and farmers' knowledge of weeds, diseases and insect pests of upland crops and the control measures used. Farmers were shown photographs of insects (both beneficial and pest). In Battambang, farmers did not use any botanical insecticides to control insect pests. They used insecticides (Folidol, Phosdrine) on mungbean but no chemicals were used on soybean, cowpea, maize or peanut. Farmers are aware of the biology of some insects but are not aware of beneficial insects such as the predatory shield bug, black beetle predator and parasitic fly (*Tachinid*) which were considered as insect pests by the farmers.

The field experimental program in Cambodia in 2004 included 11 experiments in the early wet season and 35 experiments in the main wet season. The 2005 wet season has involved a total of 35 experiments: 16 variety trials; six experiments to evaluate resistance to major

pests; nine rhizobium inoculation experiments and four reduced tillage experiments across several crop species:

- yields of mungbean varieties ranged from 650-1440 kg/ha, cowpea from 320-602 kg/ha, soybean from 150-760 kg/ha and maize from 1627-4267 kg/ha. The local mungbean varieties were poor in comparison with those from AVRDC and Thailand. In contrast, the local varieties of cowpea performed best. The best maize varieties were from Mexico and the local composite variety was amongst the lowest yielding.
- the response to rhizobium inoculation in mungbean was 6 per cent and for soybean, 20 per cent. The yields of inoculated treatments were not significantly different from nitrogen application. Inoculation could be worth $8US/ha for mungbean and $35US/ha for soybean. The cost of inoculation would be less than $5US/ha therefore inoculation could be attractive for soybeans even if the inoculum were to be imported.
- zero-tillage compared to disc and chisel ploughing produced equivalent yields for maize and higher yields for soybeans thus demonstrating that tillage is not required on the friable vertisol and ferrosol soils in upland cropping areas. Lack of ground cover however is an important problem.

Socio-economic surveys carried out in 2003 and 2004 have provided data on: profiles of farm family households; land area, capital and borrowings; and crop sequences, yields and prices. Farmers considered the main reasons for not growing crops to be lack of knowledge, low profitability, land/soil constraints, lack of labour/equipment, agronomic and climate risk.

In Cambodia some farmers have had two successive crop failures during the early wet season of 2005 due to drought and risk of sowing appears to be a major issue that requires further climate and economic analysis. The risk could be reduced by reducing the amount of ploughing and increasing the amount of ground cover but this is not likely to be enough to prevent crop failure during very dry years. Lack of crop residues and ground cover at the beginning of the wet season is a problem. The project is focussed on developing and validating sowing rules and moisture retention strategies particularly for the early wet season.

A software package containing crop growth models, database management, and analysis programs is being used. DSSAT uses weather data/other inputs to simulate crop growth for single crops or crop sequences, and evaluate crop management practices at a site. This includes running two preliminary analyses on maize management with early wet season planting options and nitrogen fertilizer management.

A workshop on “Farming Systems for Crop Diversification in Cambodia” was held at CARDI from 15-17 February 2005. The workshop, organised by CARDI and sponsored by the Crawford Fund and ACIAR was attended by 42 delegates from CARDI and from the Ministry of Agriculture, Forestry and Fisheries (MAFF), Provincial Departments of Agriculture, Forestry and Fisheries, (PDAFF) in Kampong Cham and Battambang. The workshop program included:

- concept of farming systems,
- principles of conservation farming systems; Tillage systems and crop establishment; Weed management; Work safety,
- current upland farming systems practice in Cambodia,
- demonstration of the rapid soil nitrate test,
- rhizobium inoculation on leguminous crop, and
- economics relating to margin definitions and examples, budgets including cash flow budgets, and a whole farm budget overview.

Project ASEM/2003/007: Cambodian Agricultural Research Fund

Overseas Collaborating Countries	Cambodia
Commissioned Organisation	Consultant, Australia
Project Leader	Dr John Schiller Phone: 07 3365 2987 Fax: 07 3365 1188 Email: j.schiller@uq.edu.au
Collaborating Institutions	Cambodia Agricultural Research and Development Institute, Cambodia
Project Budget	$818,743
Project Duration	01/03/2002 to 30/06/2006
ACIAR Research Program Manager	Dr Ken Menz

Project background and objectives

ACIAR manages the Cambodian Agricultural Research Fund (CARF), a component of the AusAID-funded 'Cambodian Agricultural Research and Development Institute Assistance Project'. CARF was established in 2002 to provide Cambodian scientists with an opportunity to compete for agricultural research funds. It is open to government, university or college and NGO organisations based in Cambodia, which have the clear ability and mandate to implement research within Cambodia. The aim of the Fund is to provide an environment of competitive tender for agricultural research. Seed funding and initial management of the fund will be provided by the Australian Government, through ACIAR and AusAID. In the medium term, it is expected that the CARF will be institutionalised within Cambodia. Other donors will be encouraged to contribute to the trust fund and/or support projects linked to trust fund projects.

Project progress

Year 3 (01/07/2004 to 30/06/2005)

The fourth round attracted the largest number (36) of project proposals yet, showing that interest in Cambodian-run competitive grants is strong. Once again, the applications came from a wide range of organisations, which enabled continued involvement of a diverse group of partner organisations in CARF projects. A particular feature of this round was investment in a number of activities at the Department of Agronomy and Agricultural Land Improvement, building on the FAO and the Danish Agency for Development Assistance investment in integrated pest management and activities in crops areas at the Royal University of Agriculture, linking to a new German Agency for Technical Cooperation-funded faculty development program. Projects selected for funding were:

Royal University of Agriculture:

- promotion of Dragon fruit (Red Pitaya, *Hylocereus var.*) cultivation experiments and sustainable propagation of planting material,
- the System of Rice Intensification in the Cambodian context,
- the promotion of cultivation of saprophytic edible mushroom and the development of sustainable spawn supply,
- seed production by semi-artificial breeding of snake skin gourami (*Trichogaster pectoralis*) in Svay Rieng Province,
- extension of technique of fish nutrition utilisation for small-scale aquaculture in Kg Speu province,
- technology transfer to the farming community in Kg Thom Province – breeding and nursery technologies for *Babodes altus* and *Trigogaster petoralis,*
- a study of women's power in agricultural management in Kg Svay District, Kampong Thom Province (student project), and

- a study of the effect of fruit dropping on postharvest quality of 'Keochen' mango (student project).

APHEDA (NGO)

- experimentation on high nutrition, low cost, fish foods for domestic freshwater pond fish farming.

Maharishi Vedic University

- improvement of cattle nutrition by the introduction of appropriate forages in Kamchai Mear, Prey Veng Province.

(National) Department of Agronomy and Agricultural Land Improvement

- a study on the infestation of coconut hispine beetle and its biological control, and
- production and use of local parasites to control diamondback moth on cruciferous crops in Cambodia.

Cambodian Agriculture Research Development Institute (CARDI)

- banana improvement for Cambodian farmers,
- identification of banana cultural practices, cultivation management, and prospects for improving production and growers' incomes,
- trends in productivity and nutrient dynamics under improved soil nutrient management techniques for rice in the rainfed lowlands of Cambodia,
- improvement of watermelon for Cambodian Farmers,
- post-harvest loss reduction in rice damage due to rats and insect pests, and
- improving rice grain quality by controlled drying of paddy.

Kampong Cham National School of Agriculture

- assessment of improved rice production technology in Stung Trang district, Kg Cham province.

Prek Leap National School of Agriculture

- improvement of groundnut management and production through farmers' participatory research.

The potential future of CARF is by institutionalisation of a competitive grants program through a Cambodian Agricultural Research and Extension Council that has been proposed for establishment. The concept is supported by the Cambodian government but the sub-decree for the Council has not yet been signed. It is likely to sit under the Ministry of Agriculture, Forestry and Fisheries (MAFF) but include the wider range of research providers in the sector, to provide greater communication and coordination. As part of the development of the Asian Development Bank-funded *Master Plan for National Agricultural Research, Cambodia* program with the MAFF, a number of other priority-setting exercises are underway.

In March 2005, CARDI staff also held an in-house seminar on eight current CARF projects. Several projects will have publishable results and/or lead to introduction of improved germplasm. A number of projects link to (or have been forerunners for) other donor investments, such as by ACIAR or FAO. Over early 2005 plans were commenced on re-starting the Cambodian Journal of Agriculture as a vehicle for publishing results of CARF projects and of other research carried out in Cambodia. It was last published in 2002 after 5 issues had been produced. ACIAR has committed to support publication for 3 years, with funding for visits by a professional editor from Australia to train Cambodian editorial staff in all aspects of journal publication and management and a technical specialist to assist authors of articles that arise from CARF research work.

Project ASEM/2003/012: Improving the marketing system for maize and soybeans in Cambodia

Overseas Collaborating Countries	Cambodia
Commissioned Organisation	University of Canberra, Australian Institute for Sustainable Communities, Australia
Project Leader	Professor John Spriggs Phone: 02 6201 2317 Fax: 02 6201 2263 Email: john.spriggs@canberra.edu.au
Collaborating Institutions	Ministry of Commerce, Cambodia Cambodian Development Resource Institute, Cambodia
Project Budget	$399,949
Project Duration	01/07/2004 to 31/12/2006
ACIAR Research Program Manager	Dr Ken Menz

Project background and objectives

Agriculture in Cambodia has been dominated by rice, much of it grown by smallholder subsistence farmers. The Royal Government of Cambodia has set poverty reduction and improved rural development as top priorities. To achieve this Government is focusing on the development of commercial, export-oriented agriculture. Diversification in cropping from rice is one component of this work. Among non-rice crops maize and soybean are particularly important. Both have, after rubber, the highest export potential, but marketing arrangements for the two crops are largely informal and poorly developed. Constraints include postharvest inefficiency, inadequate information flows, high transport costs and lack of external market linkages, with Thailand and Vietnam representing the main external markets. For export potential to be realised these constraints need to be overcome.

ACIAR is supporting complimentary research both to improve maize and soy production and help in crop diversification. Strengthening and developing marketing systems is needed to ensure the increased productivity delivers the benefits of exporting to nearby markets. Mapping of the marketing system, including supply chains and the institutional environment will substantially aid in identifying areas for development and focus by key stakeholders as they address constraints to the system's development. The project aims to improve the well-being of participants of the maize and soybean marketing systems, with particular attention being given to the well-being of rural families and rural development by:

- mapping the existing (formal and informal) marketing systems for maize and soybeans and its institutional environment (governmental and infrastructural), to identify the constraints and capacities for change and to evaluate the potential for improvement ,
- facilitating a process of change within these marketing systems, and
- enhance the capacity of relevant people and institutions in Cambodia.

Project progress

Year 1 (01/07/2004-30/06/2005)

The use of community-based decision-making can bring about positive socio-economic change in the Cambodian soybean and maize marketing systems through including the community of interest and various participants of that marketing system. The year began with a significant capacity-building workshop for the Cambodia-based members of the research team.

Two major decisions made during the workshop and reflected in the research action plan were:

- to focus only on the market catchment (i.e. production) area in eastern Cambodia during 2005. The eastern catchment area produces primarily soybeans for the South Vietnam market, while the western catchment area produces both maize and soybeans for the Thai market, and
- that mapping of the marketing systems should contain a macro component (looking from the system-wide perspective) and a micro component (looking from the perspective of a particular farmer association trying to develop group marketing).

At the macro-level the most important issues for the eastern catchment area appeared to be: lack of cheap credit, farmers not organized, lack of extension/training, lack of market information, not enough good quality seed and high fuel cost (due to the high fuel tax). A micro-level survey of the Ta Ong Soybean Association in Chamcarleu, Kampong Cham in the eastern catchment area revealed the issues of a lack of good quality seed and lack of low-interest credit. The Association had attempted, in the past, to access a government-run low-interest credit program but found this a difficult experience. The project is working with the Association to help them access this and to write up their experience as a case study. A survey of buyers of Cambodian soybeans in South Vietnam is also underway.

A stakeholder workshop for the eastern catchment area is planned, addressing:

- the Marketing System for Cambodian Soybeans,
- the Market for Cambodian Soybeans in South Vietnam, and
- strengthening the Ta Ong Soybean Development Association.

Project CIM/1999/048: Increased productivity of rice-based cropping systems in Lao PDR, Cambodia and Australia

Overseas collaborating countries	Cambodia, Laos
Commissioned Organisation	University of Queensland, Department of Agriculture, Australia
Project Leader	Dr Shu Fukai Phone: 07 3365 2340, 07 3365 2165 Fax: 07 3365 1177 , 07 3365 1188 Email: s.fukai@mailbox.uq.edu.au
Collaborating Institutions	National Agriculture and Forestry Research Institute, Laos International Rice Research Institute, Philippines Cambodia Agricultural Research and Development Institute, Cambodia CRC for Sustainable Rice Production, Australia
Project Budget	$1,291,106
Project Duration	01/07/2000 to 30/06/2006 (Project extended from 01/07/2005 to 30/06/2006)
ACIAR Research Program Manager	Mr John Cullen

Project background and objectives

In Lao PDR and Cambodia, rice is the staple foodstuff and also the most important crop economically. The most common rice-growing system in these countries is lowland and rain-fed. Most rice grown in this way is consumed directly by the subsistence farmers who grow it. There are few inputs to the system, and the productivity is low. One crop is grown per year, occurring in the wet season. Poor soil nutrients and periodic droughts are also constraints. There is little doubt that yields could be increased with rice cultivars that are productive even under conditions of reduced water and low soil fertility. Laos and Cambodia are still new at breeding rice and systematic research does not take place.

However, there have recently been changes in the rice cultivars used, with a tendency towards shorter-duration cultivars, planting seed earlier and hence earlier harvesting. This opens the possibility of growing a second crop (of rice or another plant). Another option is the development of direct seeding technologies, which eliminate the need to transplant rice seedlings - a procedure that can result in losses. The disadvantage of direct seeding is that weeds compete with the rice. The project will therefore examine planting methods, direct seeding and the development of suitable cultivars for use in the two countries. In Australia, the problems are different, and cultivars are required that can grow well during the early part of the season when it is cooler. This issue will also be examined, and suitable cultivars could be of benefit to areas of northern Laos. The project focuses on use improving rice-breeding and agronomic techniques so as to increase productivity and improve stability mainly in lowland rice-based cropping systems in Lao PDR and Cambodia.

Project progress

Year 5 (01/07/2004-30/06/2005)

Plant breeding strategies for rainfed lowland rice: Information on variety adaptation across varying rice growing environments in Lao PDR is limited. Previous ACIAR projects have investigated the magnitude of genotype by environment (G×E) interaction under different fertiliser conditions in three provinces and found relatively stable conditions of varieties across varying nutrient conditions. There is no evidence of the magnitude of G×E interaction in Laos with a large environmental and climatic variation.

Determining the magnitude of G×E interaction across the rice growing environments in Lao PDR and if any genotypes among the existing breeding population can be used for wide adaptation to different growing conditions in the country is underway. Forty-eight genotypes were selected from the Lao breeding program, drought screening experiments and

introductions from Thailand's breeding program for inclusion in experiments during the 2004 wet season and the 2004–05 dry season. These selections were tested at Savannakhet, Champassak, Luang Namtha and Xieng Khoung under normal farmer practice using transplanting establishment methods. The results suggested that GxE interactions are significant. The genotype by environment variance indicated that yield performance of a selected set of genotypes is inconsistent across four provinces. Fifteen high yielding genotypes were identified. There were a number of better performing genotypes than the existing popular genotypes, at four locations. These lines were selected from the breeding program and most of the improved lines had a higher yield than the traditional and popular varieties. The results of 2004–05 dry season experiments will be analysed with the 2004 wet season data in order to test the genotype by season interactions.

In the 2004 WS, 23 genotypes were examined in multi-location trials (MLTs) in 8 locations throughout Cambodia. These MLTs identified some genotypes with a higher grain yield than the traditional landrace material, which will be used as parents for the rice breeding program. In addition, a farmer participatory selection program was initiated with 25 farmers in Chrey Veal. The farmers selected three varieties based on visual assessment of plant type, duration, grain shape and grain yield.

Intensification of rice-based cropping systems in rainfed lowlands: The development of double cropping systems to increase on-farm productivity is vital for farmers in Cambodia and Laos. In Cambodia, areas with high rainfall or supplementary irrigation had a low risk of double cropping for rice in the early wet season and wet season. There was a high risk of crop failure of the early wet season rice in low rainfall areas where supplementary irrigation was not available. Rice-rice double cropping was possible for most areas where good rainfall was received in early April during the early wet season. There were difficulties for double cropping mungbean in the early wet season with rice in the wet season due to high rainfall causing water-logging in the early wet season and drought conditions in the dry season. Experiments were also conducted at Luang Namtha and Xieng Khoung in the 2004 wet season and the 2004–05 dry season in northern Laos to further test the likelihood of rice-rice double-cropping under irrigated conditions. Crop establishment in the dry season was successful as there was no extremely low temperature during sowing in the dry season. The annual grain yield was increased to 8-9 t/ha when rice-rice double cropping was adopted under irrigated condition in the dry season.

Development of direct seeding technology A row seeder was used for direct seeding experiments and demonstration trials in irrigated conditions in the dry season at Vientiane Province. Several farmers demonstrated that they could significantly reduce the cost of establishment and weed control by adopting new technology. Direct seeding in the dry season was recommended for Vientiane as it produced a consistently higher yield compared to transplanting. Direct seeding in the wet season failed several times due to problems associated with water control.

Increasing productivity of dry season irrigated rice: The main constraint in growing rice in the dry season at higher altitudes is low temperature during seedling establishment. One option to provide farmers with a more flexible planting period in these high altitude areas is to use a plastic dome over the seedbed to protect the developing seedlings from low temperature in December-January. The project has successfully developed and demonstrated a simple nursery protection method using locally available plastics. Several farmers from Xieng Khoung and Luang Namtha demonstrated that the technique was a practical solution to low temperature problems. The farmers who have participated in on-farm experiments in 2003/04 DS have achieved a 20% higher grain yield compared to the yield of the crop that was established under the conventional unprotected nursery.

Agro-ecological characterisation: In 2004, six agro-climatic zones were developed for Laos based on temperature, rainfall and altitude data. The country has tropical, subtropical and mountainous zones. These zones are further divided into humid and sub-humid areas according to water availability. The maps also consider water availability at a greater level of specificity than what previously was available. Water availability in rice paddies is complicated because of downward and lateral water movement; the project quantified these components

for better estimation of paddy water environments. The agro-climate zone map provides sufficient information to determine where different crops can be grown, based on climatic information alone. Crop suitability maps utilizing climate as well as soil and topography information, were developed for Savannakhet to identify areas suitable for different crops. These maps still require further testing for their accuracy in predicting crop suitability in different areas before they can be used by development planners.

Water balance study include

- supply in paddy fields under rainfed conditions is determined primarily by rainfall, and frequent rainfall events can retain standing water in the field until a critical growth phase,
- in sloping lowlands, water losses by downward and lateral movement are greater in areas higher in a topo-sequence, and the lateral water loss possibly becomes a water input in the areas of lower topo-sequence,
- water availability in the fields that lies in lower topo-sequence is greater, resulting in higher productivity,
- in the fields in higher topo-sequence, greater reduction in yield often occurs due to low plant water availability.

This will not be the case where much water runs on to the fields in higher topo-sequence from catchments above the fields. In addition, the water balance study has shown that the rainfed lowlands in southern Laos potentially encounter the late season drought, implying low productivity in those years with low rainfall, and that the water productivity generally decreases with late flowering in the rainfed lowlands.

Project CIM/2003/030: Improving understanding and management of rice pathogens in Cambodia

Overseas Collaborating Countries	Cambodia
Commissioned Organisation	NSW Department of Primary Industries, Orange Agricultural Institute, Australia
Project Leader	Dr Eric Cother Phone: 02 63913886 Fax: 02 63913899 Email: ric.cother@agric.nsw.gov.au
Collaborating Institutions	Cambodia Agricultural Research and Development Institute, Cambodia Charles Sturt University, Australia
Project Budget	$399,997
Project Duration	01/07/2005 to 30/06/2008
ACIAR Research Program Manager	Mr John Cullen

Project background and objectives

Rice is Cambodia's most important staple crop, occupying 90 per cent of all agricultural land. Several diseases; brown spot, rice blast, false smut, bakanae and kernel smut are the most common. Little information is known about the distribution, prevalence or impacts of these diseases in Cambodia. Local plant pathology expertise is very limited, hindering a greater understanding of such diseases. To develop this understanding the project will train Cambodian researchers in basic plant pathology techniques. Once trained Cambodian and Australian scientists will collect samples to identify pathogens of rice and losses they cause. The final stage of the project will develop disease management strategies appropriate to local conditions.

Project progress

Year 1 (01/07/2005 to 30/06/2006)

The first progress report is due mid-2006.

Project CP/1997/079: Integrated control of mango insect pests using green ants as a key element

Overseas Collaborating Countries	Thailand, Vietnam
Commissioned Organisation	Charles Darwin University, Faculty of Science, IT and Education, Australia
Project Leader	Associate Professor Keith Christian Phone: 61 8 8946 6706, 08 8946 6666 Fax: 61 8 8946 6847 Email: kchristi@cdu.edu.au
Collaborating Institutions	Prince of Songkla University, Thailand Southern Fruit Research Institute, Vietnam Department of Agricultural Extension, Thailand
Project Budget	$655,210
Project Duration	01/01/2001 to 30/06/2005 (Project extended from 01/07/2004 to 30/06/2005)
ACIAR Research Program Manager	Dr T K Lim

Project background and objectives

Mangoes are an important smallholder and commercial crop in Vietnam, Thailand and other Southeast Asian countries, and one of the most important commercial crops in northern Australia. To achieve good yields with top quality fruits, mango growers currently rely on regular pesticide applications. This leads to increased costs, the reduction of natural predators and parasitoids on the insect pests, increased pest resistance to insecticides, pesticide residues in the fruits and environmental pollution.

Green ants are efficient predators of a wide range of insect pests in many tropical fruit crops and they are abundant and widely distributed in Southeast Asia. Previous work in Indonesia and preliminary results from cashew crops in northern Australia indicates that green ants can control some of the main pests of mangoes.

Experiments in a mixed-cropping mango orchard using the ants together with limited applications of insecticides indicate that an integrated pest management (IPM) model for mango orchards can be constructed. Since Vietnam, Thailand and Australia all share similar insect pests of mangoes their exists common ground for collaborative research amongst the three countries.

The project aims to develop an IPM program by using green ants as a major biological control agent together with agricultural strategies and the selective use of insecticides to reduce populations of homopteran pests in mangoes in Vietnam, Thailand and Australia.

Project progress

Year 4 (01/01/2004-31/12/2004)

In Vietnam and Thailand, the yield and the fruit quality produced in the treatment with weaver (green) ants plus environmentally friendly soft chemicals (WPS) were similar to or higher than in the chemical insecticide treatment (CI), while in the Northern Territory, Australia, the profit from WPS or from trees with abundant weaver ants was increased by over 70 per cent compared to the profit in CI or in trees without weaver ants.

Compared to chemical insecticides, weaver ants were effective in controlling the major mango insect pests. These include mango leafhoppers, thrips, fruit spotting bugs, flower caterpillars, seed weevils, fruit flies, elephant beetles, stem borers, planthoppers, leaf cutting weevils, web caterpillars and seed borers.

Although weaver ants have a mutual relationship with scales and mealy bugs, the soft chemicals were effective in reducing the populations of these pests, and these soft chemicals are safe for weaver ants. Weaver ant formic acid caused black spots on fruit skin mainly due to ant fights between colonies. Separation of weaver ant colonies is effective in reducing the levels of fruit damaged by the formic acid.

Weaver ants are aggressive, annoying people working in orchards during harvest. Water spray can greatly reduce the ant activity prior to harvest, and it does not cause fruit lenticels or post-harvest diseases. Mango growers are pleased with this method in Australia. In Thailand, farmers found a picking pole or net with a long handle plus shaking action after a few picks to be useful to reduce the disturbance from the ants. In Vietnam, two methods are used to reduce ant disturbance: rubbing wood ash on the main branches of the relevant part of the tree to break ant trails when harvesting; and luring the ant away from the trees, which will then be harvested or pruned.

Weaver ants do not have a detrimental impact on the level of parasitism of Homopteran pests in mango orchards. The mixed cropping orchards harbour more natural enemies of the insect pests compared to the monoculture orchards. To stabilise weaver ant populations in mango orchards, it is essential to isolate the ant colonies, transplant ant colonies with queens and mix mango trees with other tree crops such as citrus. If mango orchards are monoculture, the provision of ant food is needed when trees are in dormancy.

Two types of IPM programs for both organic and conventional growers have been successfully developed for mango growers in Vietnam, Thailand and Australia. These IPM programs are friendly to the environment, and they allow mango growers to significantly cut chemical insecticide use and to produce insecticide-free or organic fruits.

Educational materials targeting farmers (Booklets, video (DVD and tapes) and a series of posters) in English, Vietnamese and Thai have been produced to describe how to use the IPM program step by step. The research group is actively involved in publications, communications, dissemination and extension activities. Throughout this project, the project staff have produced 10 publications, 18 research presentations and 5 major research reports, and they have also conducted 8 major communication and extension activities.

Farmers in Vietnam, Thailand and Australia who are involved in this project are happy with the IPM programs, and they have adopted the methods. The Pest Management Center in Khon Khan Province, Thailand tried the IPM program in 2004, and they achieved better results than they expected. They will continue to use weaver ants for their oriental fruit fly research in Udorn Thani Province. The owner of the Supan Buri site, Department of Agricultural Extension of Thailand was happy with the yield, and the mango growers nearby expressed their willingness to use the ants in their orchards.

Project CP/2001/027: Adaptation of low-chill temperate fruits to Australia, Thailand, Laos and Vietnam

Overseas Collaborating Countries	Laos, Thailand, Vietnam
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Maroochy Horticultural Research Station, Australia
Project Leader	Dr Alan George Phone: 07 5441 2211 Fax: 07 5430 4994 Email: alan.george@dpi.qld.gov.au
Collaborating Institutions	Research Institute of Fruit and Vegetables, Vietnam National Institute of Plant Protection, Vietnam National Agriculture and Forestry Research Institute, Laos Southern Fruit Research Institute, Vietnam Department of Agriculture, Thailand
Project Budget	$388,981
Project Duration	01/07/2001 to 30/06/2007 (Project extended from 01/07/2004 to 30/06/2007)
ACIAR Research Program Manager	Dr T K Lim

Project background and objectives

This project extends previous research investigating the development of a sustainable temperate fruit industry in Thailand. Temperate fruit industries in Thailand are in the early stages of development, but high prices are paid for temperate fruits in Thai domestic markets. The production of high-value temperate fruits would raise living standards of hill tribe people and encourage them to use sustainable cropping systems. There is also an export market window into other Asian countries from March to May.

Vietnam already grows many fruit crops and the average revenue from fruit production is two to three times higher than that of rice. It is estimated that many more areas are suitable for temperate fruit production. Laos only grows poor-quality local varieties but has other suitable areas to grow low-chill temperate fruit. The problems for growing temperate fruits in Vietnam and Laos are similar to those that have been identified in Thailand: development of insect pests and diseases during high humidity, lack of knowledge on how to select the best varieties and manage the crops, lack of nurseries, and lack of marketing studies or plans.

The project aims to establish and develop sustainable low-chill temperate fruit industries (stone, pomegranate fruit and persimmon) in Thailand, Laos and Vietnam through the identification of appropriate sites and varieties and through the implementation of best management practices at the farm level.

Project progress

Year 4 (01/07/2004-30/06/2005)

Laos

With temperate fruits, nectarine was the preferred fruit for marketing in Lao PDR in contrast to Thailand where peach is preferred. Prices received for the newly introduced varieties (about A$1.50 per kg) are quite high compared with local selections.

Field sites Trees exhibit signs of poor shoot extension growth due to a combination of drought and over cropping. Farmers are still reluctant to heavily thin trees to get adequate size. The concept of thinning is foreign to Lao farmers as they see it as wasteful. Unfortunately, excessive crop loads can lead to a decline in tree health and eventually death. A new field site was selected on the Plain of Jars on a commercial property with excellent soil structure and good drainage. The Plain of Jars region has suitable topography, soil types and water

availability for large scale horticultural production. About 200 trees of seven, introduced varieties of peach, plum, nectarine and persimmon were planted.

A new block of about 160 stonefruit and persimmon trees was established at the Kang Pho Research Station. The soil type at this site is less suitable for horticultural production because of its clay texture. Trees will need to be heavily mulched to encourage surface feeding.

Establishment of fruit nursery A small nursery has been set up at the PAFO Horticultural sub research Centre near Ponsavan. Following inspection of the new nursery recommendations were made for methods to improve the facility. Project personnel also demonstrated how to germinate 6000 peach rootstock seed, which were introduced as part of the project, and how to prepare a well drained potting mix.

Training The training in Lao PDR was ably assisted by the two Thai DOA experts, one of who will visit Lao PDR again later in the project to assist the regional extension officers in training and managing the peach demonstration sites.

Thailand

Project extension An extension methodologies workshop was conducted at the Royal Project Office in Chiang Mai. The workshop was attended by farmers and extension staff from DOAE, Highland Project and Royal Project Foundation. A better understanding of the constraints to expanding temperate fruit production in Thailand was developed. Further meetings are planned to better co-ordinate extension activities across agencies.

Four farmer sites have been established near Khun Wang research stations with between 150 to 250 trees planted on each site. The oldest trees, at one site, are now 3 to 4 years and producing good quality fruit. Tree age at the other sites ranges from 2 year-old to recently-planted. The main variety being tested is the peach cultivar Tropic Beauty. To increase returns most of the farmers have interplanted this with cash crops including flowers, coffee, or vegetables.

About 100 Tropic Beauty peach trees have been established at four farmer sites in Ang Kang Province, bordering the Myanmar border. These trees are between 1 to 2 years old and should fruit next year.

Linkages with the World Vision project A meeting was held in Chiang rai with the Australian and Thai project leaders for the ACIAR—World Vision project. This was followed up with a visit to field sites of stonefruit at Ban Kon Village and neighbouring sites. Overall there had been a significant improvement in the management of the sites. Over 400 trees of newly introduced varieties such as the peach cultivar Tropic Beauty have been successfully established and fruited. Training was conducted for farmers and World Vision extension staff with a Thai DOA research officer undertaking monthly visits to the sites to supervise and further train the World Vision extension officers.

Project CP/2005/035: Survey toolbox for plant pests - A practical manual for surveillance of agricultural crops and forests

Overseas Collaborating Countries	Cambodia, Indonesia, Philippines, Thailand, Vietnam
Commissioned Organisation	Department of Agriculture Fisheries and Forestry, Animal and Plant Health, Australia
Project Leader	Ms Lois Ransom Phone: 02 6271 5118 Fax: 02 6271 5835 Email: lois.ransom@daff.gov.au
Collaborating Institutions	Not applicable
Project Budget	$100,000
Project Duration	01/01/2004 to 30/11/2005
ACIAR Research Program Manager	Dr T K Lim

Project background and objectives

Increasing trade liberalisation has brought with it obligations for countries seeking WTO access. One of these is the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). This outlines domestic regulations for handling the presence of contaminants that may be found in traded commodities, including guidelines and international standards. Nowhere does this impact more than in the trade of agricultural commodities, the main export hope of many developing countries. The SPS Agreement requires countries to have well founded quarantine, technical and scientific capacities, areas in which most developing countries are under-resourced. Provision of a survey toolbox for plant pests will help in devising surveillance programs and other protocols to meet the requirements under the SPS Agreement.

Project progress

Year 1 (01/01/2004-31/12/2004)

- The initial table of contents were developed based on available literature.
- The proposal contents were then discussed at a workshop attended by the Reference Group. The Reference Group consisted of scientists from the Philippines, Papua New Guinea, Vietnam, Indonesia, Thailand, Fiji, Malaysia and across Australia. Observers from ACIAR and the co-funding body RIRDC also attended. The workshop was highly successful with relevant presentations and useful feedback and suggested improvements given. For example, it was agreed that the use of case studies were of great interest. Attendees identified relevant categories of surveys that would be most widely relevant and then volunteered to write the studies. Ideas about how the guideline structure and detailed entries might be improved were provided by all.
- Following the workshop, the ideas have been collated and worked in to a restructured table of contents which was sent electronically to the Reference Group for comments.

Project FIS/2000/061: Development and delivery of practical disease control programs for small-scale shrimp farmers in Indonesia, Thailand and Australia

Overseas Collaborating Countries	Indonesia, Thailand
Commissioned Organisation	NSW Department of Primary Industries, Australia
Project Leader	Dr Dick Callinan Phone: 02 6688 6289 Fax: 02 6626 1276 Email: richardcallinan@versa.com.au
Collaborating Institutions	Directorate General of Fisheries, Indonesia Network of Aquaculture Centres in Asia Pacific, Thailand Asian Institute of Technology, Thailand James Cook University, Australia Queensland Department of Primary Industries and Fisheries, Australia Aquatic Animal Health Research Institute, Thailand Department of Fisheries, Western Australia, Australia
Project Budget	$1,014,019
Project Duration	01/07/2001 to 31/03/2006 (Project extended from to 31/03/2006)
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

The world production of farm shrimp in 1996 was valued at over $10 billion. About 80 per cent of the crop is produced in Asia, largely by small-scale farmers. In Thailand, 90 per cent of shrimp farms are smaller than 1.6 ha, while in Indonesia almost 50 per cent are less than 2 ha. In Australia, the bulk of producers are also small farmers that operate on average on 15 ha of ponds. *Penaeus monodon* is the most important farmed shrimp species in Southeast Asia and Australia. Infectious diseases are consistently identified as the major threat to the long-term viability of the shrimp farming industry in the Asia-Pacific region, and recurrent massive outbreaks of viral diseases have caused serious financial losses among smallholders.

To address this situation, researchers have worked towards developing effective farm-level, shrimp disease-control programs. This work has now produced relevant expertise and information, but because of lack of definitive, on-farm program validations and inadequacies in the delivery of extension programs, smallholders have generally failed to benefit. The main aim of this project is for farmers, scientists and extension workers in Indonesia, Thailand, and Australia to acquire the necessary knowledge, practical skills and willingness to implement, retain and continue publicising the shrimp disease-control programs that have been developed for small-scale shrimp farms. Additionally, the project aims to support an existing shrimp disease and coastal management study in India.

Project progress

Year 3 (01/02/2004-30/04/2005)

In general, project activities have established that health management programs are eagerly sought and can be successfully implemented, extended and disseminated amongst small-holder farmer groups. This success is now recognised at senior departmental levels in participating countries, where the project is seen as a model for embedding better health management practices at farm level, as part of wider ‘good aquaculture practice’ and ‘code of conduct’ programs.

Solid progress also continues in Indonesia, despite an unexpected setback in South Sulawesi province. Programs in East Java have now been successfully implemented on clusters of

semi-intensive as well as extensive farms in Sidoarjo and Gresik districts, with an overall success rate of 88 per cent. By contrast, identical programs implemented in Pangkep and Maros districts in South Sulawesi produced a failure rate of 90 per cent. The differences were attributed to an unexpected risk factor of the light, sandy soil at the Pangkep site which apparently facilitated disease transmission from infected, non-participating farms to adjacent project farms. Additional biosecurity measures involving clusters of farms are planned to address this problem. Importantly, the project is moving beyond its initial target areas in Indonesia, with programs now being implemented, after unsolicited requests from farmers, at new sites in West Java and Lombok. Project extension staff have produced a health management manual and CD (in Bahasa Indonesia) which is being widely disseminated amongst farmers and extension providers at both existing and new entrant project sites.

Changed circumstances in Thailand have markedly impeded program adoption at farm level, particularly at the more marginal Chacheongsao site. These include the almost complete shift in Thailand from the target *P. monodon* to *P. vannamei*, for which less health management information is available in the small-holder context. The recent emergence of 'monodon slow-growth syndrome', the causes of which are still uncertain, has influenced many farmers not to grow this species. Drought and low shrimp prices are also factors. In addition, both the Project Leader (Thailand) and the Project Scientist-Extensionist have been redeployed, although both will remain active in the project until its conclusion. Despite these changes, there has been considerable progress in the extension area; project staff have produced a comprehensive health management manual, together with brochures and a poster (all in Thai), covering both *P. monodon* and *P. vannamei*. This information is now being widely disseminated through farmer groups and government extension centres in shrimp-farming provinces.

The following determinants for successful program adoption and farmer-led dissemination have been identified:

- sufficient science-based information on control and prevention of important endemic diseases for the species being farmed,
- shrimp farming must be an important industry in the target province and district,
- land use and environmental data must confirm that the location is suitable for some intensification of shrimp farming,
- social and economic data should confirm that intensification of farming will not negatively affect local communities,
- national-level fisheries agencies must support incorporation of program elements into existing best aquaculture practice and code of conduct programs,
- provincial and district-level extension agencies must support program implementation,
- local farmers must be organised into groups and be enthusiastic about implementation,
- initial program demonstrations in any locality should, where possible, be run simultaneously in 'key farmer' ponds and in government-operated ponds, and
- each of the following must be available within the target province: (a) a hatchery capable of supplying good quality seed stock to participating farmers; (b) a reliable, accurate PCR test provider; (c) a reliable, accurate disease diagnostic laboratory.

In India, solid progress continues at the study site in West Godavari district, Andhra Pradesh. Building on the success of earlier demonstration work, programs are currently being implemented on 917 ponds belonging to 547 farmers in 16 villages.

Project FIS/2002/068: Improving feeds and feeding for small scale aquaculture in Vietnam and Cambodia

Overseas Collaborating Countries	Cambodia, Vietnam
Commissioned Organisation	Department of Fisheries, Western Australia, Fremantle Maritime Centre, Australia
Project Leader	Dr Brett Glencross Phone: 08 9239 8103 Fax: 08 9239 8105 Email: Bglencross@fish.wa.gov.au
Collaborating Institutions	Can Tho University, Vietnam Royal University of Agriculture, Cambodia Lake Argyle Industries Pty Ltd, Australia Research Institute for Aquaculture No. 1, Vietnam Aquaservice, Vietnam
Project Budget	$711,460
Project Duration	01/01/2004 to 30/06/2007
ACIAR Research Program Manager	Dr Geoff Allan

Project background and objectives

Aquaculture, or fish farming, is the fastest growing food production sector in the world. It is being seen as a sustainable solution to the growing pressure that increased fishing activities are placing on wild resources. Advances in culturing fish are reducing the capture of wild juvenile fish, to then grow to size, boosting the value of fish farming. But further advances are needed to ensure aquaculture itself remains a viable and sustainable option for smallholders and the environment alike. One component where advances could enhance sustainability is in fish diets. Most fish farmers do not buy commercial feeds. The high cost of these are not adequately returned in the market price of fish. Farmers make their own feeds using available ingredients, such as rice bran and trash fish. Often these formulations do not sufficiently meet the nutritional needs of growing juvenile fish. To compensate some farmers ensure excess food and nutrients are available, eating into profit margins and increasing the likelihood of environmental impacts.

In Vietnam and Cambodia smallholder farmers are keen to get involved in aquaculture. The main barrier is a lack of information on the ingredients for diets. This, when assessed against the nutritional needs of fish species farmed, can help in formulating optimal diets. Differences in feed requirements also extend to the stage of development; high protein and energy required in juvenile fish is not always suitable for maintaining health in fully grown fish. Bio-energetic modelling, using these variables, can define protein and energy requirements and then guide the formulation of diets using local ingredients to match these parameters. The overall aim of the project is to enhance the development of sustainable aquaculture using locally (Vietnam/Cambodia) derived ingredients and better formulated feeds to:

- develop diets based on locally-available ingredients for improved production of (*Pangasius* catfish and tilapia in southern Vietnam, *Pangasius* catfish in northern Vietnam and Cambodia and barramundi in Australia),
- demonstrate/evaluate the potential of new improved feeds in on farm trials, and
- transfer technology and extend information.

Project progress

Year 1 (01/01/2004-31/12/2004)

*Develop diets based on locally-available ingredients for improved production of catfish and tilapia*_Progress has been made in collecting a range of ingredient samples for a collective ingredient database. Collection of these samples continues to build a critical number to allow

analysis of all samples together. Determination of the nutritional value of key ingredients will begin in July 2005.

Nutritional requirements of fish species in Vietnam & Cambodia: Growth data and samples of tilapia and catfish from commercial farms have been collected in both northern and southern Vietnam. Data collected and samples yet to be analysed, will be used in constructing preliminary factorial growth models in June 2005. This review will also allow for data assessment to identify gaps where further samples and/or farm data are required. Maintenance energetics trials on tilapia and catfish have been conducted in northern and southern Vietnam. Sample analysis from these trials is also pending. Only an energy utilisation efficiency trial is required for both tilapia and catfish to enable the initiation of complete energetic models for these species.

Transfer technology and extend information Workshops among the project participants were held in September 2004 and more are planned for 2005. These workshops serve to develop technical capacity in the partner country collaborators and also review existing data-sets collected.

Project FIS/2002/075: Application of PCR for improved shrimp health management in the Asian region

Overseas Collaborating Countries	India, Indonesia, Thailand
Commissioned Organisation	CSIRO Livestock Industries, Australian Animal Health Laboratory, Australia
Project Leader	Dr Peter Walker Phone: 03-5227 5165 Fax: 03-5227 5555 Email: Peter.Walker@csiro.au
Collaborating Institutions	Mahidol University, Thailand Directorate General Aquaculture, Indonesia Network of Aquaculture Centres in Asia Pacific, Thailand Agency for Marine and Fisheries Research, Indonesia
Project Budget	$715,921
Project Duration	01/01/2005 to 31/12/2007
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Shrimp farming, or culturing, is a profitable industry. Successful culturing provides income and employment for smallholder farmers, as well as those working in hatcheries, larger-scale farms, feed mills and processing plants. Most of this has flow-on effects as income is redistributed throughout the usually poor rural communities, many located in coastal regions that practice shrimp culturing.

In addition to these benefits farming of shrimp is sustainable. This relieves the pressure placed on wild populations being harvested at unsustainable catch levels, motivated by reaping the potential income on offer. Thailand leads the world in farmed shrimp production, with Indonesia and India, like many other countries in Asia, both major and growing producers.

For the past decade the Asian industry has been limited by disease outbreaks. Several have been serious enough to cause declines that if continued unabated would threaten the industry. Two diseases in particular, white spot syndrome virus (WSSV) causing white spot disease and yellow head virus (YHV) have caused these declines. Past ACIAR research has developed polymerase chain reaction (PCR) and epidemiological tests to identify the diseases. These are used to detect the viruses in seed stock and live shrimp respectively. Despite these being widely adopted outbreaks continue, and a slow growth syndrome has become more prevalent, prompting further research into PCR use and its role in ongoing farm management. The project will focus on:

- reducing the risk of White sport disease in shrimp farms through the application of PCR-based detection tests and epidemiological probes,
- reducing the risk of yellow head and other shrimp diseases in shrimp farms through application of PCR-based detection tests and epidemiological probes, and
- improving the effectiveness of PCR-based viral screening in hatcheries and service laboratories in India, Indonesia and other countries in the Asian region.

Project progress

The first progress report is due early in 2006.

Project FIS/2002/077: Improved hatchery and growout technology for marine finfish in the Asia-Pacific region

Overseas Collaborating Countries	Indonesia, Philippines, Thailand, Vietnam
Commissioned Organisation	Queensland Department of Primary Industries and Fisheries, Australia
Project Leader	Dr Mike Rimmer Phone: 07 4035 0109 Fax: 07 4035 6703 Email: Mike.Rimmer@dpi.qld.gov.au
Collaborating Institutions	Southeast Asian Fisheries Development Centre, Philippines Central Research Institute for Aquaculture, Indonesia Research Institute for Aquaculture No. 1, Vietnam Network of Aquaculture Centres in Asia Pacific, Thailand Sam Ratulangi University, Indonesia Research Institute for Coastal Aquaculture, Indonesia Gondol Research Institute for Mariculture, Indonesia CSIRO Marine Research, Australia
Project Budget	$887,710
Project Duration	01/07/2004 to 31/12/2007
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

Aquaculture is an important source of supply, particularly of high-value marine finfish. Interest in pursuing this has grown, reflecting both the incomes on offer to smallholders and the potential easing of pressure on wild stocks, both driven by the lucrative (up to US$70/kg) paid in some parts of Asia.

The sustainability of aquaculture production continues to grow, as research delivers improvements to fish grow-out survival rates. ACIAR-supported research (FIS/1997/073) developed improved diets and rearing strategies for some species. Despite this success some problems remain to be addressed: wild fry and fingerlings being used as a source of seed stock, the poor survival in rearing from larvae and the role of trash fish (low value species usually found as by-catch in fishing for higher-value species).

With marine finfish playing an important role in the economic well-being of many coastal communities, ensuring the sustainability of aquaculture is important to maintaining wild fisheries. Without such production fishing pressure on wild stocks will increase, fisher folk will increasingly be forced to trawl for trash fish and increasing numbers of wild fry and fingerlings will be removed from wild populations to act as a source of seed stock.

The overall objective of the project is to enhance the sustainability of marine finfish aquaculture in the Asia-Pacific region by improving hatchery production technology and facilitating the uptake of compounded feeds for grow-out.

Project progress

Year 1 (01/07/2004-30/06/2005)

Many of the research activities of FIS/2002/077 have been delayed by various changes within the participating agencies. This has necessitated a major revision of the project, and has effectively delayed its implementation by 6–12 months.

Hatchery technology
Preliminary sampling has been carried out to assess the nutritional requirements of grouper larvae, and to identify the causes of the deformities that are commonly seen in hatchery-reared fish in Indonesia.

Grow-out feeds
Evaluation of the use of poultry offal silage meal to replace fishmeal in grouper diets indicated that the inclusion of poultry offal silage meal at rates up to 20% (equivalent to a 37% replacement of fish meal protein) had no significant effect on fish growth, survival or carcass composition of juvenile *E. fuscoguttatus*. Higher levels of replacement may be beneficial but possible deficiencies of methionine, histidine and lysine may have to be overcome through the use of crystalline amino acids or complementary protein sources.

Asia-Pacific Marine Finfish Aquaculture Network
Extension and coordination activities, carried out through the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN), have continued from the earlier grouper aquaculture project (FIS/97/73). Private sector support for APMFAN has been provided by Skretting, who provide support for the electronic publications (eNews and eMagazine) and are sponsoring four participants in the grouper hatchery training course over two years.

The results of FIS/97/73 were published as an ACIAR Monograph (no.110 – *Advances in Grouper Aquaculture*) and around 1,750 hard copies have been distributed and over 196 downloads of the electronic version recorded.

Two practical extension guides were produced:

- A Guide to Small-Scale Marine Finfish Hatchery Technology
- A Practical Guide to Feeds and Feed Management for Cultured Groupers

Around 150 hard copies of each have been distributed, and 1,364 and 870 downloads (respectively) of the electronic versions recorded. These two guides are currently in the process of translation into Indonesian, Thai and Vietnamese for distribution to farmers and investors in Asia.

Twenty-six issues of the APMFAN eNews were produced up to 30 June 2005, and three issues of the APMFAN eMagazine were produced. The distribution list for electronic publications is now around 1,088.

The 3rd Regional Grouper Hatchery Production Training Course was successfully carried out at the Brackishwater Aquaculture Development Centre, Situbondo, East Java, Indonesia from 18 April to 8 May 2005. There were participants from Australia, Brunei Darussalam, Indonesia, Malaysia, Maldives, Marshall Islands, Singapore, and Vietnam. Skretting sponsored a private sector participant from Vietnam as part of that company's support for APMFAN. APMFAN sponsored a fisheries officer from Aceh to participate in the training course as part of the capacity building for rebuilding the aquaculture sector in Aceh.

The first Study Program on Marine Aquaculture and Seafood Markets in Southern China (Guangzhou, Dayawan, Shenzhen, Shanwei, Yau Ping and Hong Kong) was successfully carried out from 4–15 July 2005 as an APMFAN activity. The Study Program was organised by the Network of Aquaculture Centres in Asia-Pacific (NACA), in cooperation with the Guangdong Provincial Bureau of Ocean and Fisheries, Guangdong Fishery Society, Guangdong Dayawan Fishery Development Center (Department of Marine and Aquatic Products, China), the Agriculture, Fisheries and Conservation Department (AFCD) – Hong Kong SAR. The Study Program introduced participants from exporting and producing regions in the Asia-Pacific area to the markets and marine aquaculture in southern China. There were 14 participants from China, Hong Kong, India, Indonesia, Maldives, Marshall Islands, Philippines, and Singapore.

The process of formalising participation in APMFAN is continuing. The Terms of Reference for Regional Resource Experts and Regional Resource Centres have been developed (based on those developed for the NACA Aquatic Health Management Program) and an official letter has been sent to member governments.

Project FIS/2003/003: Stock structure of two important Mekong River carp species (Henicorynchus spp.)

Overseas Collaborating Countries	Cambodia, Laos, Thailand, Vietnam
Commissioned Organisation	Queensland University of Technology, School of Natural Resource Sciences, Australia
Project Leader	Dr Peter Mather Phone: 07 3864 1737 Fax: 07 3864 1535 Email: p.mather@qut.edu.au
Collaborating Institutions	Mekong River Commission, Fisheries Programme, Cambodia Living Aquatic Resources Research Centre, Laos Department of Fisheries, Thailand Research Institute for Aquaculture No. 2, Vietnam
Project Budget	$318,785
Project Duration	01/01/2004 to 31/12/2005
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

The Mekong River Basin is home to fisheries which provide food security for approximately 60 million people spread across several countries. Despite their importance management of these fisheries is rudimentary at best. The Mekong River Commission (MRC), formed under the cooperation of the four countries sharing the lower parts of the basin, have begun to focus on achieving sustainable fisheries management to ensure food security is maintained, while also factoring in growing development pressures on the river. The basin offers a wide range of agricultural and industrial development opportunities. Hydrological power development is one such opportunity that threatens fisheries, while the importance of the river as a trade link between the six riparian countries through which it runs, is also likely to increase. Population increases will continue to put further pressure on the surrounding environment and river system itself, as well as on the capabilities of Mekong fisheries.

Management of these fisheries is complicated by the high level of diversity of fish species. Sustainable management practices can vary between species depending on ecology and life histories. The MRC has initiated extensive studies of the ecology of a number of important fish species to understand ecology and life histories better. The use of genetic methodologies for identifying discrete gene pools has not been used in the Mekong. Elsewhere these techniques are being applied to dish stock discrimination to form the basis of fisheries management plans. The application of these techniques is possible for the Mekong and will be trialled. Project work will determine the pattern of genetic structure of two economically important carp species (*Henicorynchus siamensis* and *H. lobatus*) as models and to develop an appreciation of the conceptual basis, data interpretation and application of molecular population genetic analysis to fisheries management in the MRB.

Project progress

Year 1 (01/01/2004-31/12/2004)

Samples of both study species (*Henicorynchus siamensis* and *H*. *lobatus*) were collected, some purchased from local fishermen on the river and at the local riverside markets. Pectoral fin clips were taken from both species and stored in 70 per cent ethanol for later analysis. Whole fish were preserved and catalogued for future morphometric analysis.

Fishes previously collected by MRC scientists from the Mekong River at Phnom Penh were sampled, catalogued and preserved with both species also collected from around Tonle Sap Lake. Samples were taken from five sites (Kampong Chhang, Pursat, Battambang, Siem Reap and Kampong Thom) situated on the shores of the lake. Subsequent samples were collected at Stung Treng in northern Cambodia by the MRC.

Using a modification of a salt extraction method, total genomic DNA has been extracted from all samples from Tonle Sap Lake along with 20 individuals each from Stung Treng, Phnom Penh and Chau Doc. Two fragments of DNA from the mitochondrial genome have been investigated for their utility in addressing specific questions regarding the population structure of both species. The first fragment is a 350 bp segment of the Control Region (non-coding) and the second incorporates the entire ATPase 6 and 8 protein coding genes with a total of approximately 950 bp.

Sequence analysis ruled the mtDNA Control Region fragment out for further project work due to it being variable to be useful with reasonable sample sizes (i.e. <100). By optimising running conditions for screening the mtDNA ATPase fragment for variation using Temperature Gradient Gel Electrophoresis (TGGE) this should be useable. At this stage only preliminary results from DNA sequencing of a limited number of samples are available, leading to two initial conclusions. Firstly, low levels of divergence among sampling sites seen thus far indicate that a significant amount of gene flow may occur across the extent of the lower part of the Mekong River (i.e. below the Khone Falls). However it must be stressed that further data is needed to verify this statement as significant haplotype frequency differences may exist over greater spatial distances.

Secondly, the level of genetic divergence between the two species appears to be of a magnitude often associated with that seen among different genera rather than among congenerics (an average of approximately 15 per cent divergence is seen among Cyprinidae genera while the divergence between *H. siamensis* and *H. lobatus* is 13 per cent for the ATPase fragment). Therefore it may be assumed that the two species under investigation are likely to display very different biologies (until recently *H. siamensis* and *H. lobatus* were considered the same species). Similar morphologies may reflect convergent evolution rather than common ancestry.

Project FIS/2005/030: Dissemination of findings on the "best practice approach" to culture-based fisheries through a series of workshops in selected developing countries in Asia

Overseas Collaborating Countries	Laos, Thailand, Vietnam
Commissioned Organisation	Network of Aquaculture Centres in Asia Pacific, Thailand
Project Leader	Dr Thuy T. T. Nguyen
Collaborating Institutions	Not applicable
Project Budget	$48,740
Project Duration	10/01/2005 to 31/12/2005
ACIAR Research Program Manager	Mr Barney Smith

Project background and objectives

The objective of this project is to disseminate and share experiences gained through ACIAR projects relating to culturing fish in inland reservoirs. This will be achieved through a series of workshops with local fish farmers, aquaculture planners and developers in Bangladesh, Laos PDR and Cambodia. ACIAR projects in Sri Lanka and in Vietnam on reservoir-based aquaculture have been successful in bringing out legislative changes that could stimulate growth. These projects have also been responsible for recognition and incorporation of culture-based fisheries in the fisheries development plans. Culture based fisheries are an effective way of increasing fish food supplies to rural areas, at an affordable price, and provide income to rural farmers, thereby contributing to poverty alleviation.

Project progress

Year 1 (10/01/2005 – 10/01/2006)

The first progress report is due in early 2006.

Project FST/1994/019: Genetic diversity and propagation of mangroves

Overseas Collaborating Countries	Thailand, Vietnam
Commissioned Organisation	Southern Cross University, Centre for Coastal Management, Australia
Project Leader	Professor Peter Saenger Phone: 02 6620 3631 Fax: 02 6621 2669 Email: psaenger@scu.edu.au
Collaborating Institutions	Royal Forest Department, Thailand Vietnam National University, Vietnam
Project Budget	$717,021
Project Duration	01/07/1999 to 31/10/2005 (Project extended from 01/07/2004 to 31/10/2005)
ACIAR Research Program Manager	Dr Russell Haines

Project background and objectives

Mangrove forests are a well known feature of coastlines in the tropics and subtropics. They are very important in protecting and stabilising coasts in cyclone-prone areas. They act as a nursery for many fish species of economic importance and a habitat for other fauna. They can also be an important resource for local people, providing them with wood and other products. Mangroves are now heavily exploited in many parts of the world. Wood-gathering and fishpond operations are the main threats. Other pressures are mining and mineral extraction, diversion of freshwater (which damages mangrove roots), the development of coastal areas with associated silt and pollution, the construction of channels and harbours, and the disposal of wastes.

About 80 higher plant species, from several different groups, are considered as mangroves. There is thus considerable variety in mangrove forests. This diversity is generally reduced by exploitation or other damaging pressures. Once damaged or destroyed, it is hard to re-establish mangrove forests. The survival rate of seedlings is naturally low, and this difficulty is compounded by a lack of seed availability to establish re-planting programs. It's also important to know what types of mangroves to plant where. If reforestation of degraded mangrove areas is to be successful and appropriate conservation strategies defined, it will be necessary to improve the collection, storage and transport of mangrove germplasm (the seeds) and to understand better the intricacies of mangrove genetics.

Several developing countries have asked ACIAR to help with the problem of obtaining adequate supplies of desirable germplasm to set up mangrove plantations. These requests were the origins of this project. This project aims to improve our knowledge of the genetic variation existing in selected species of mangroves, and then to produce and disseminate germplasm of high quality varieties. The work is expected to benefit mangrove conservation and reforestation in South and Southeast Asia.

Project progress

Year 6 (01/07/2004-30/06/2005)

A microsatellite library has been established for *Avicennia marina* (Maguire et al. 2000a) in order to be able to characterise the genetic variation that exists within and between populations of this species. The results indicate that microsatellites are abundant in the *Avicennia marina* genome and can be valuable genetic markers for assessing gene flow in mangrove communities.

Microsatellite analysis of the genetic structure of this mangrove has also been undertaken, based on six Australian (Qld, NSW, Vic, SA, WA and NT) populations and on populations from South Africa, United Arab Emirates, India, Japan, Malaysia, Papua New Guinea, New

Caledonia and New Zealand. This analysis strongly indicated that there was considerable genetic diversity between the various populations of this species and that gene flow was very limited between them. In addition, many populations have “private alleles” (unique alleles found only in the one population). A comparative study of AFLP (Amplified Fragment Length Polymorphisms) and SSR (Simple Sequence Repeats or Microsatellites) techniques for analysis of genetic diversity in *Avicennia marina* has shown that either, or a combination of both techniques, is applicable to expanded studies of mangroves (Maguire et al. 2001). SSRs are particularly suitable for population-based investigations. AFLPs are more suitable for monitoring propagation programs and identifying duplicates within collections.

It has been established that the distances germplasm naturally moves through pollen and propagule dispersal is in the order of Laura’s main outputs. This has important implications when considering introducing non-local germplasm for maintenance or enhancement of natural genetic diversity in restoration programs. Also established are differences in growth characteristics seen in *Avicennia marina* from different parts of Australia as having a genetic (genotype + genotype/environment interaction) rather than an environmental basis.

A successful protocol for the micropropagation of *Avicennia marina* from both seed-derived explants and field-derived explants was developed. A technique for dissecting and establishing the growing seedling from mangrove seeds in aseptic culture was devised to successfully provide enough plant material for investigative media trials. This method is also successful through all the stages of tissue culture to produce a healthy potted plant. Although it does not involve an increase in numbers, it could provide large numbers of plants for field plantings at specified times such as outside the typhoon season in Vietnam.

Callus can be induced from specimens of anthers and ovaries, propagules and mature leaves of *Avicennia marina*. However, callus inducing specimens are still small in quantity and the callus induced suffered from a slow growth rate.

The natural distribution of *Rhizophora apiculata* has been surveyed in the Gulf, East and South of Thailand. The Queensland Department of Primary Industry now require that to conserve genetic integrity mangrove regeneration sites should only use propagules produced in the same catchment as the regeneration area.

Project LPS/1998/026: Lucerne adapted to adverse environments in China and Australia

Overseas Collaborating Countries	China, Laos
Commissioned Organisation	South Australian Research and Development Institute, Plant Research Centre, Australia
Project Leader	Dr Geoff Auricht Phone: 08 8303 9498 Fax: 08 8303 9607 Email: auricht.geoff@saugov.sa.gov.au
Collaborating Institutions	Department of Agriculture, Western Australia, Australia University of Tasmania, Australia Gansu Agricultural University, China Shandong Academy of Agricultural Sciences, China Beijing Forestry University, China Chinese Academy of Agricultural Sciences, China Gansu Grasslands Ecological Research Institute, China International Centre for Tropical Agriculture, Laos
Project Budget	$938,899
Project Duration	01/01/2001 to 30/06/2007 (Project extended from 01/01/2005 to 30/06/2007)
ACIAR Research Program Manager	Dr Bill Winter

Project background and objectives

Sustainable agricultural production is vital for China. As the country develops, demand for animal products is increasing. However, the country faces a severe shortage of forage, as well as many environmental problems such as increasing soil salinity, acidity and erosion. The vast grassland areas are not very productive, partly due to inappropriate management but also because of unimproved pasture plants and deforestation. Australia also has related problems of salinity and waterlogging caused by a lack of deep-rooted perennials plants to keep watertables low. Part of the solution to these problems may come from lucerne, which is a nutritious, productive perennial forage legume, with the potential to improve animal production and soil stability, and lower watertables. Interest in lucerne is growing, often in places where it was previously considered unsuitable.

Currently, lucerne is sown in 14 provinces in China, and covers 1.33 million ha. It also grows wild in other regions of the country. However, it could be grown far more widely. But the current lucerne is under-utilised, because of the poor performance of the cultivars grown, coupled with a lack of suitable technology and quality seed. A diverse base of germplasm is already available for lucerne, with a range of tolerances to adverse soil and climatic conditions. But research is required to develop lucerne germplasm specifically adapted for the situations in China and Australia. This large project will target salt, waterlogging, acid/aluminium and cold tolerance by developing new screening techniques and using them to identify tolerant genotypes. The project aims to produce lucerne varieties that are adapted to environmental stresses relevant to China and Australia through the development of germplasm and novel screening techniques.

Project progress

Year 4 (01/01/2004-31/12/2004)

Acquisition and field testing of germplasm: The germplasm being grown at the Waite Campus in Adelaide has been characterised over a full year. Characterisation of rhizobia collected from Chinese soils was continued and diversity of material estimated using molecular markers. Measurement and assessment of trials has continued at all sites in China and Australia using a revised measurement protocol. Multiplication continued with new larger scale plots established by the Gansu Agricultural University collaborators at Jingtai, Gansu.

Further trials were established in Laos with the collaborators. Forty-eight lucerne trials were established across two provinces, five districts and 28 villages. The establishment of these trials was excellent with all trials showing excellent germination and early growth. Although all the trials were successfully sewn, relatively few were growing well by November. This is thought to be largely due to soil acidity and poor soil fertility at the selected sites. These are predominantly on acid soils where lucerne would not normally be expected to perform well in the absence of treatments such as liming. However, other soil types exist in Laos, for example in the valley floors or on limestone hilltops, where better lucerne performance would be expected. Future trials will now target these new areas.

Developing novel screening techniques: Aluminium screening continued with the first of the progeny from previous selections tested against the parent material. The results of these experiments revealed the progeny were much more aluminium tolerant than the parent material. Further selections were made from this material and will be available for retesting. A large amount of acid soil from Mt Pleasant SA was collected for use in validating the screening work and experiments commenced to characterise this soil. Salinity work continued in Tasmania with a range of parameters measured to characterise the response to salt stress of genetically diverse plant material. Material with different genetic background appears to have different tolerance mechanisms and this may reflect adaptation to differing levels of salt stress.

Delivering well-adapted germplasm to seed producers and breeders: Some of the commercial entries in the Chinese trials performed so well in the trials that registration of this material will commence in 2005. The aluminium tolerance screening has already supplied material to breeding programs and retested the progeny of this material. Further selection cycles will continue in 2005.

Training and extension: A number of project related papers were published in Chinese journals. Another paper was published from the screening work. Project research was also presented at the International Crop Science Congress in Brisbane and at the International Conference on Plant Anaerobiosis. Project activities and research have featured in a number of articles in Australian electronic and print press.

Project LWR/1998/119: Impact of heavy metals on sustainability of fertilisation and waste recycling in peri-urban and intensive agriculture in south-east Asia

Overseas Collaborating Countries	Thailand, Vietnam
Commissioned Organisation	CSIRO Land and Water, Australia
Project Leader	Dr Mike McLaughlin Phone: 08 8303 8433, Mob: 0409 693 906 Int: +61 409 693 906 Fax: 08 8303 8565 Email: Mike.McLaughlin@csiro.au
Collaborating Institutions	Department of Agriculture, Thailand Asian Vegetable Research and Development Center, Taiwan Nong Lam University, Vietnam National Institute for Soils and Fertilisers, Vietnam Queensland Department of Primary Industries and Fisheries, Australia Department of Natural Resources and Mines, Queensland, Australia Department of Land Development, Thailand
Project Budget	$1,012,730
Project Duration	01/07/2001 to 31/03/2006 (Project extended from 01/07/2005 to 31/03/2006)
ACIAR Research Program Manager	Dr Ian Willett

Project background and objectives

This project developed out of a growing concern about the contamination of agricultural soils and crops in Southeast Asia and because international importers of produce are using the presence of contaminants as a means to restrict trade from these regions. A preliminary investigation — which examined soil and crop contamination in Malaysia and Thailand — found high concentrations of zinc and copper in vegetables and soils. Results also indicated: that many farmers and agricultural industries are unaware of the contaminants that are present in agricultural inputs such as fertilisers, manures, composts and pesticides; that agricultural inputs generated from municipal wastes, industrial sources and soil replacement materials are used as cheap sources of nutrients on farms; and that the intensive use of fertilisers and wastes in peri-urban agriculture leads to the accumulation of cadmium in certain crops.

Because most of the scientific understanding of the behaviour of contaminants that are present in the soil and food chain stems from research in temperate climates in developed countries, health and environmental authorities in Southeast Asia need data on which to base guidelines for contaminants in soils and crops. This project aims to provide a scientific basis for the protection of Australian and Asian soils from irreversible degradation by heavy metals and metalloids. It aims to assess the adverse impact that agricultural and industrial practices have on the soil and the crop quality in tropical regions of Southeast Asia and aims to develop strategies to limit these adverse impacts on agricultural systems and on human health. It also aims to maximise the benefits and minimise the risks associated with the use of wastes and fertilisers in peri-urban agricultural systems.

Project progress

Year 4 (01/07/2004-30/06/2005)

The data generated by the nationwide survey of heavy metals in crops and soils in Vietnam and Thailand have now been used to generate heavy metal contaminant maps for both countries. These have identified a number of regions that have higher than usual and lower than usual concentrations of some of the metals. The reasons for these will be investigated.

Field experiments examining crop uptake and toxicity of animal manures, bio-solids and heavy metals have been completed at all eight sites involved in the study and the subsequent soil analyses are being undertaken. Vietnamese soils and crops appear to be quite sensitive to small inputs of heavy metals, with threshold toxicity values being lower than those found in other countries. It is not clear whether this difference is due to the Vietnamese and Thai crops being more sensitive than Australian crops or whether it is the Vietnamese and Thai soils that are more sensitive than the Australian soils. This will be resolved by a series of toxicity tests being conducted in Australia using wheat. These will be conducted in the project's extension.

The progress and success of the project was independently reviewed in November 2004 in Ho Chi Minh City. During the review the ACIAR representative and the reviewers visited field sites, laboratories and listened to approximately one and a half days of presentations on the results of the project.

Project LWR/2001/051: Assessing land suitability for crop diversification in Cambodia and Australia

Overseas Collaborating Countries	Cambodia
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Collaborating Institutions	Department of Agriculture, Western Australia, Australia Cambodia Agricultural Research and Development Institute, Cambodia
Project Budget	$766,290
Project Duration	01/01/2003 to 31/12/2005
ACIAR Research Program Manager	Dr Ian Willett

Project background and objectives

Crop diversification can alleviate poverty by increasing income and improving nutrition for farm households. In the lowlands of Cambodia there is potential to diversify from the traditional wet season rainfed rice system by double cropping (with rice and legumes) using the abundant shallow groundwater for irrigation. Similarly, in the uplands, relatively large areas of land are available for the expansion of cropping and could be used to grow field crops and fruit and nut trees. To ensure that crop diversification is effective, information is needed on soil and climate constraints, and potential environmental impacts, to assess the suitability of land for particular crops. The land resource studies and soil maps needed for assessing land suitability are generally not available for Cambodia.

This project aims to facilitate crop diversification in Cambodia and Australia by assessing land suitability for growing crops such as legumes and field crops in lowland and upland areas of Cambodia respectively, and pulses in southern Australia.

Project progress

Year 2 (01/01/2004-31/12/2004)

In Cambodia agriculture is dominated by a single cereal crop in each case, and whereas opportunities for diversification appear to exist, there are key blockages in adoption. A more explicit description of the biophysical and socio-economic limiting factors through land suitability assessment will help to improve adoption of crop diversification. Selection of study areas was undertaken in Kampong Cham – Ou Reang Ov district in the south of the province; Takeo – Tramkak district on the western margin of the province, and Batdambang – Banan district, south of the provincial centre.

Reconnaissance and semi-detailed soil surveys The soil database of Cambodia has been updated and now includes 121 soil profile records across Cambodia including 61 from this project. Further field work and checking of the soil map occurred in Kampong Cham and Takeo. Soil samples from the profile of selected sites representing the main upland soil types of Kampong Cham and Takeo were analysed for chemical properties and mineralogy, and results compiled. These results were added to the soil database of Cambodia. The soil-landscape map of Ou Reang Ov district in Kampong Cham was finalised. A field survey of soils of Banan district, Batbambang was carried out in February with the results now being analysed. A draft soils map of the Banan district of Battambang was completed in August, and will be ground truthed in 2005.

The results of surveys with 50 farmer house-holds in each study location were finalised. Interviews covered their experience and knowledge about crop diversification with results entered into an Access database for analysis. On-farm trials to establish a benchmark for yield potential in different crops (maize, mung bean, soybean, peanut and sesame) across soils were sown in Tramkak (3 sites), Kampong Cham (4 sites) and Banan (3 sites) in mid-late May. Sesame establishment has been very poor at most sites but impressive recovery growth was observed at two of the sites in Takeo. Peanut and mung bean have been the most reliable with soybean and maize performance varying more among sites. Drought has limited growth at times at all sites but especially in northern Tramkak district where the site on a Prateah Lang soils comprises sand over clay sub-soil. A further 10 sites at Tramkak (3 sites), and Ou Reang Ov (4 sites) and Banan (3 sites) were sown in mid-late July to mid-August for the main wet season.

The same group of farmers were subsequently surveyed regarding land capability assessments in Ou Reang Ov, Tramkak and Banan districts to record farmers' knowledge on soil productivity and crop performance. Results are being entered into the database and preliminary results were presented at the project's Mid-Term Review.

Limiting factors for crops A preliminary list of limiting factors for field crops on each of the main soils types in Kampong Cham and Takeo has been prepared. Broadly, land qualities for land capability assessment will be categorised into:

- tillage- hard setting, high soil strength, stoniness, stickiness when wet
- germination and emergence-crusting, soil strength
- growth- nutrient availability, acidity, water supply (drought), waterlogging, inundation
- land and water resource degradation risk - slope, dispersion, leaching

The land qualities above will be used to develop capability ratings for the crops and soils under consideration in the present project.

Soil acidity is likely to be a significant limiting factor for field crops on many Cambodian soils. It has been largely overlooked as flooding of soils for rice production neutralises acidity. In Prey Khmer soils in uplands of western Takeo province, Al saturation values of 50-80 per cent were found in the sub-soil. Aluminium saturation > 20 per cent is commonly regarded as a potential Al toxicity in sensitive crops, whereas in very tolerant crops > 80 per cent Al saturation is required to impair crop growth. Amongst the major field crops, peanut has low-moderate Al tolerance, whereas mung bean, maize and soybean are generally low in Al tolerance. While these generalised tolerances can vary for specific cultivars, they indicate the degree to which Al toxicity may be a significant limiting factor for land capability for particular species.

Rainfall analysis An analysis of rainfall data from the provinces of Kampong Cham, Takeo and Batdambang was carried out based on records for 41 locations supplied by the Mekong River Commission. This analysis suggests that mean annual rainfall is less than some previous publications have suggested for Cambodia and heightens concerns about early wet season drought as a limiting factor for field crops. Rainfall analysis was extended to the estimation of season rules for cropping and the incidence and severity of droughts during the growing season.

Project PLIA/2000/165: Facilitating farmer uptake of ACIAR project results: World Vision collaborative program

Overseas Collaborating Countries	Laos, Thailand, Vietnam
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Collaborating Institutions	World Vision of Vietnam, Vietnam Laos World Vision Foundation, Laos World Vision Foundation of Thailand, Thailand Queensland Department of Primary Industries and Fisheries, Australia
Project Budget	$1,267,261
Project Duration	01/01/2001 to 05/03/2007 (Project extended from 01/01/2004 to 05/03/2007)
ACIAR Research Program Manager	Dr John Skerritt

Project background and objectives

Increasing the impact of ACIAR project results has been furthered through a partnership with World Vision (WV) projects where provision of technologies arising from ACIAR projects can further agricultural productivity. ACIAR entered into a Memorandum of Understanding (MoU) with World Vision for this purpose in February 2000, and this project comprises some of the major collaborative activities in Southeast Asia under this MoU. This project consists of a set of six collaborative sub-projects between ACIAR and WV in Laos, Thailand and Vietnam. Results arising from a mature or completed ACIAR project activity which are suitable for farmer-level extension are integrated into an active WV project in particular provinces the three countries.

In Thailand three subprojects are addressing agricultural productivity and impacts; firstly the use of chemicals in vegetable production and specifically preventing chemical runoff and pollution. A second sub-project is improving fish feeds for aquaculture using locally available ingredients. Finally the third sub-project is introducing improvements applicable to growing low-chill temperate stone fruits. The single Laos sub-project is seeking to introduce improved crop options by boosting wet season rice production and utilising other crops in the dry season. Two Vietnamese components—*Rodent Control in Rice Crops Using IPM Techniques* and *Improvement of Soil Fertility in Bac Binh District, Binh Thuan Province, Vietnam*—utilise technologies developed in several current or completed ACIAR projects to assist in the 'technical underpinning' of a larger WV rural development project in Binh Thuan province of southern Vietnam.

Project progress

Year 4 (01/01/2004-31/12/2004)

Chemical-free vegetables: Work to date has been aimed at developing the quality of life of farmers and consumers in order to improve farmers' health, and provide produce free from excessive chemical residues or bacteria. The Prevention of Agrochemical Pollution of Water Resources project demonstrated that a substantial decrease in the use of agro-chemicals was possible in vegetable production in key watershed areas of the Songkhla Basin without adversely affecting economic viability. The project reached a large number of direct beneficiary families (510), and an even larger audience of indirect beneficiaries. The project has provided training for extension workers. With the continued support of Prince of Songkhla University, and the increased involvement of the government extension services, the number of beneficiaries was as listed below:

- farmers trained: 1,850,

- group members: 510,
- secondary beneficiaries (estimate): 1,500, and
- expansion potential (estimate): 5,000.

Project cost represents around 15 per cent of household income on an annual basis over three years (2001–03). It was agreed that the project be extended to promote safe vegetable growing among the farmers in other areas in Southern Thailand where World Vision Foundation of Thailand (WVFT) was active, as these areas have the same economic and social problems as Kuan Niang area. Farmers in those areas still farm rice and coffee, using increasing levels of herbicide, pesticide and chemical fertilisers. Recently, many of the farmers in the areas moved to Phuket and Krabi province after the harvest season to take advantage of job opportunities. This project has shown that well-managed vegetable growing is a more profitable alternative in each WVFT implementing area (10 districts in seven provinces). The Prince of Songkhla University, Songkhla province has provided technical assistance and advice.

It is expected that within one year, there will be at least 300 new farmers, in the 10 areas, using the system of safe vegetable production developed in the project and 1,200 farmers receiving information on the system and realising the danger of the inappropriate use of toxic substances in agriculture. Moreover, the system, the manual and dissemination materials will serve as a learning source that WVFT staff can use to promote and extending the results of this project in the future.

Fish feeds from local ingredients: Improving fish farming through utilisation of low-cost feeds in the north-east region of Thailand will boost the productivity and sustainability of fish farming systems and maximise benefits for target groups via collaboration with the government and private sectors as well as community organizations and the people. Project highlights during the period included:

- development of training curriculum for fish farming,
- production runs of fish feeds at different protein levels, for evaluation and use in other provinces,
- promotion of fish farming in extended area,
- demonstration of fish raising in floating baskets (‘Kra-chang’),
- improvement of equipment for production of fish feed,
- the cooperative was proposed for government registration as an agriculture cooperative, and
- development of fish farming fund (micro-credit scheme) in the project areas.

Demonstrations were held at training centres in two target areas namely Khok Sa-ard sub district in Prasat district of Surin province and Hnong Nakham sub district in Muang district of Udon Thani province. These events disseminated educational techniques for fish farming in collaboration with extension services. The emphasis was on using proper technologies, cost reductions, and provision of best quality, affordable fish feed.

Low chill fruit production systems: Work has focused one village in Huaychomphu subdistrict, Muang district, Chiangrai—Thailand, through holistic development to apply research findings on low-chill fruit tree production. The Department of Agriculture has developed and pilot-tested the viability of low-chill fruit production in highland areas of Northern Thailand. It also acts as a core agency in training and demonstrating various techniques of low-chill orchard management to target farmers through coordinating agencies.

Currently low-chill fruit trees in the demonstration plots grow rapidly and need to be pruned, so that they are in good shape and continue growing. The project thus purchased trimmers and other tools such as saws, and gave them to the Center for use in caring for low-chill fruit trees. The project has recruited students as trainees. They help to work in the field with

getting rid of weeds, loosening the soil and help to disseminate knowledge to the community. After three months of growing trees (Tropic beauty variety), the project used fertiliser formulas.

An advisory team was formed during this period. The Chiangmai Royal Research Institute, WV's partner in this project, gave advice regarding project implementation. Changes were made from local nectarine varieties to better breeds using scions of Baan Luang Daeng and Gulf Ruby plum varieties. Vegetable growing demonstrations also took part in the low-chill fruit orchards, so that farmers could apply this to their individual orchards.

Crop options in Laos: Improving food crop yields in Central Laos will contribute to improved household food and economic security. Extending and applying research output, to achieve increases in wet season food crop (particularly rice) production, using proven, low-input, sustainable technologies in these rice-based agricultural systems continued using proven extension methodologies. These methodologies revolve around a small number of farmers, two in each of 10 villages, who will establish guided demonstration plots on their land. Currently 10 villages in each district have benefited from the project. The total number of villages invited to participate in the project will be determined after consultation with each district, and after considering relative needs, resources (especially the irrigation water available), progress and capacity. The farmers have been trained in the technologies to be used and the protocols for establishing and managing the demonstration plots. A mix of both small (experimental size) and large plots (field scale) are used to demonstrate and compare the technologies such as new varieties and fertiliser input.

Linkages are being furthered between extension and research staff at district, provincial and national levels. At the national level there will be representation of the National Agriculture and Forestry Research Institute (NAFRI) and the National Rice Research Program. At the provincial Savannakhet-level there will be an important involvement of the Thasano Rice Research and Seed Multiplication Centre. Both of these organisations have taken part directly in related ACIAR projects and been key partners in the Lao-IRRI project. Important links will be maintained with the ACIAR Lao projects involve the School of Land and Food Sciences of the University of Queensland, together with direct consultative and technical inputs from the Brisbane-based former leader of the Lao-IRRI Project.

Project SFS/2000/007: Farmer-based adaptive rodent management, extension and research system in Cambodia

Overseas Collaborating Countries	Cambodia
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Project Web Site	http://www.communityzero.com/camfarmers
Collaborating Institutions	Cambodian Department of Agricultural Extension, Cambodia Cambodia Agricultural Research and Development Institute, Cambodia Australian Agency for International Development, Australia
Project Budget	$307,554
Project Duration	01/07/2001 to 30/06/2006 (Project extended from 01/07/2005 to 30/06/2006)
ACIAR Research Program Manager	Dr Simon Hearn

Project background and objectives

The rat is the most important pest of rice in Cambodia. Rat problems are likely to get worse with increased cropping intensity. Farmers have traditionally managed rats in various ways e.g. using zinc phosphide bait, trapping, digging burrows, hunting, and plastic fences. Sometimes, this has been supported by a bounty on rat tails. There is scope to improve existing practices both by improving the techniques of rat management used by individual farmers and by greater attention to concerted action by communities. Previous work in Cambodia showed the usefulness of community-based approaches based on the concerted action of individuals pursuing their own practices and on novel technology (such as the active trap barrier system - TBS), and managing the latter as a community resource. TBS technology has been developed elsewhere in the region but the economic and social aspects of this technology are poorly understood.

Management of the TBS as a common property resource (i.e. at a community level) may provide a means to overcome this problem. This also means that the technical aspects of the technology and the social arrangements that support it have to be melded together. An ACIAR-funded rodent project has advanced the knowledge of rodent pest ecology and control in Southeast Asia. This project is building on this large ecological knowledge base.

The project will investigate the technical, social and economic aspects of rodent pest management in Cambodia. The researchers will identify appropriate social institutions for managing the trap barrier system as a common property resource at a village level; evaluate various technological options for improved rodent management in Cambodia, and promote a greater familiarity with, and acceptance by the Cambodian Agricultural Research and Development Institute of community-based approaches to technology development.

Project progress

Year 4 (01/07/2004-30/06/2005)

To facilitate the transformation of advances in understanding rodent ecology into development outcomes, ACIAR has funded this project to investigate factors affecting the adoption of the community TBS in Kampong Cham Province in Cambodia. The key findings of this project indicate that the adoption of the technology is limited because the cost of establishing and maintaining the community TBS is justified when rodent damage to crops is high. A community TBS must be implemented in the rice field at the transplanting stage so that a lure crop is planted inside the TBS. However, farmers cannot make a timely decision whether or not to implement a community TBS because it is too early to forecast rodent damage to crops

at the transplanting stage. However, a number of farmers at the project site have adopted and improved the community TBS in areas where high rodent damage occurs each year. The financial support from the project (e.g., supply of trap and fence materials) for the community TBS has been gradually phased out from 40 per cent of total cost in 2003 to nothing in 2004. The number of TBS groups, the number of participating farmers, and the quality of TBS construction and maintenance did not decline over this period, indicating that the community TBS is self sustainable.

The most commonly used rodent control method in Southeast Asia has been and will continue to be the application of zinc phosphide bait. This is because the bait has been the most affordable technology for rice farmers. A group of key farmers designed and implemented bait trials to develop improved methods of zinc phosphide baiting. They found that bait uptake and palatability was improved by replacing maize with rice as the bait base. They also learnt to manufacture wax block bait with technical inputs from the project. They prefer to use wax block bait because they are weather resistant and not palatable to non-target species such as chickens, dogs and other domestic animals.

The participating farmers have improved both the TBS and zinc phosphide baiting technologies. They played the role as trainers in workshops to teach other farmers to use these technologies. Although the primary aim of these workshops was to field test the extension material developed by the project, the workshops did achieve extension of the technologies to farmers from nearby communes. However, the success of the extension was limited geographically because only farmers near the project site could attend the workshops. The project was not designed to extend the technologies.

Extension material for community TBS have been developed and used for training workshop and general distribution through the government network. The extension material is currently being updated because of the continuing improvements made by the participating farmers of the project. Extension material for zinc phosphide baiting technologies is being developed and will be available in by the end of 2005. The extension material has been drafted in Khmer and will be finalised and distributed to researchers and extension workers in Cambodia through the government network by the end of 2005.

Project SFS/2004/016: A systems approach to rodent management in upland environments in Lao PDR

Overseas Collaborating Countries	Laos
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Collaborating Institutions	National Agriculture and Forestry Research Institute, Laos World Vision in Lao PDR, Laos
Project Budget	$215,939
Project Duration	01/01/2005 to 31/12/2006
ACIAR Research Program Manager	Dr Simon Hearn

Project background and objectives

Shifting cultivation remains one of the dominant production systems in many upland areas throughout Southeast Asia. Many of the rural communities practising this traditional agriculture are very poor. In the uplands of Laos this pattern holds true, with smallholders amongst the poorest in Asia. Lao farmers practicing shifting cultivation in upland areas grow rice, maize, sorghum and other crops. Rodent pests are a major production constraint. Farmers cite this as the problem they have the least control over. Past ACIAR research has developed a population-based control, the community trap barrier system (TBS). The TBS uses a lure crop, planted ahead of the main crop and traps strategically placed around a barrier encasing this lure crop, to trap sufficient quantities of rodents to break population cycles, which coincide with crop cycles.

Past project work in Laos introduced the TBS concept, established for lowland irrigated rice, into an upland, shifting cultivation setting. Farmers adapted this to protect stored grain but found it had limited impact in the field. Rodent population data, together with data on past rodent outbreaks, were also collected. This will now be used to test rodent management practices amongst farmers. Existing knowledge, attitudes and practices will be evaluated to help adapt and adopt a rodent management system suitable for upland shifting cultivation settings, by:

- developing robust management solutions for rodent management in upland shifting cultivation systems based on understanding of population dynamics of the key rodent pests and to prepare a manual on rodent control,
- determining the sociological and cultural factors that influence farmers' decisions on the adoption of rodent management through conducting pre- and post-survey of knowledge, attitudes and practices in Laos, and
- developing the capacity and involvement of government and NGO extension for establishing adoption pathways of ecologically-based rodent management.

Project progress

Year 1 (01/01/2005 – 31/12/2005)

The first progress report is due in 2006.

Project CP/2000/002: Development of advanced technologies for germplasm conservation of tropical fruit species

Overseas Collaborating Countries	Malaysia, Philippines, Thailand, Vietnam
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Collaborating Institutions	Griffith University, Australia Department of Agriculture, Thailand Institute of Agricultural Genetics, Vietnam University of the Philippines at Los Banõs, Philippines Universiti Kebangsaan Malaysia, Malaysia
Project Budget	$746,479
Project Duration	01/01/2003 to 31/12/2005
ACIAR Research Program Manager	Dr T K Lim

Project background and objectives

The Asia, Pacific and Oceania region has more than 400 tropical fruit species that are can provide income, nutrition, medicine, timber, fuel and livestock feed, only a few of which have been exploited commercially. Tropical fruit species and their wild relatives play an important role in stabilising and sustaining ecosystems, particularly in Asia. Several native species are rapidly approaching extinction; thus, there is an urgent need to conserve this diversity. However, many species of tropical fruit are difficult or impossible to conserve by traditional methods such as seedbanks or field genebanks, and there are currently no efficient, appropriate methods for their long-term, sustainable conservation. New in vitro technologies are therefore needed for conserving tropical fruit species. Such technologies are the subject of this project, which will complement an Asian Development Bank funded project, *Conservation and use of tropical fruit species biodiversity in Asia*, that is being implemented by the International Plant Genetic Resources Institute (IPGRI). The Asian Development Bank project involves 10 countries, including the Asian countries involved in this project.

This project aims to conserve the genetic resources of selected tropical fruits and related species by developing new conservation methods and regeneration strategies, and disseminating these technologies to researchers and others within the Asia, Pacific and Oceania region.

Project progress

Year 2 (01/01/2004-31/12/2004)

Cryopreservation studies for the identified crops (mango, papaya, Australian native fruits, *Nephelium*, citrus, persimmon, litchi and longan) were performed using materials propagated in Year 1. Preliminary cryopreservation studies were already reported for some crops like papaya, citrus and Australian native fruits in Year 1.

Somatic embryogenesis have been developed for Citrofortunella microcarpa, Citrus reticulata, C. aurantifolia, C. sinensis and C. suhuiensis and multiple shoot formation was obtained for Citrofortunella microcarpa, C. reticulata and C. hystrix. Protocols have been refined for micropropagation and shoot and plantlet regeneration via organogenesis of some Australian native fruits. Micropropagation and plantlet regeneration from in vitro nodal cuttings of three Australian Citrus species (Citrus inodora, C. garrawayi and C. australasica) has been achieved. Adventitious shoots were obtained for both litchi and longan. Persimmon callus was

formed and used for cryo-assays. Adventitious buds were formed from embryonic shoots of persimmon.

Genetic fidelity testing for tissue cultured and non-tissue cultured plants of *Citrofortunella macrocarpa, C. reticulata*, *C. aurantifolia* and *C. grandis* were evaluated using 11 enzyme systems and no differences was found in banding patterns between tissue cultured and non-tissue cultured plants. In developing cryopreservation techniques, seed desiccation sensitivity was tested for *Citrus reticulata, C. sinensis, C. medica, Citrofortunella macrocarpa, C. aurantifolia, C. hystrix* and *C. nobilis* as well as for longan seeds and excised embryonic axes of persimmon. Experiments with desiccation of *C. australasica* seeds showed tolerance to ultra low temperatures and had normal morphology post-cryopreservation. In another study, the optimum duration was found for *C reticulata* and *C. nobilis.*

Encapsulation dehydration (ED) and vitrification methods were tried for several Citrus varieties with successful recovery. The results suggested that ED may not be a suitable technique for cryopreservation of somatic embryos. Cryopreservation of embryonic axes of *C. grandis* using ED method was performed and the results provided initial data on the potential of cryopreservation of *C. grandis* embryonic axes. Promising results were obtained for *C. hystrix* as well using the ED method. Cryopreservation of mature *Citrofortunella macrocarpa* seeds using desiccation proved to be a very simple method of preserving its germplasm. Embryogenic callus of Som-Keaw-Wan (*C. reticulata*) Som-Shokun (*C reticulata*), Som Chengh (*C. sinensis*) were cryopreserved using new ED. Results showed that pretreatment affected the percentage of moisture content after desiccation in various time. The results of this experiment showed that new ED with pretreatment solution was better than conventional ED. For *C reticulata* and *C. nobilis*, the pregrowth duration had significant effect on survival of its cryopreserved embryonic axes.

Papaya shoot tip cryopreservation protocol was improved to be applicable to a wide range of genotypes by optimization factors influencing vitrification. Eight different genotypes were selected to compare the old and refined protocol and all were successfully cryopreserved with recovery rates varying from 36 per cent to 60 per cent. Preliminary tests for cryopreservation of *Nephelium* were carried out. Progress on developing a suitable cryopreservation method for this difficult species has been made and the results obtained so far has provided guidance on the approach for further work.

For Australian native species, shoot tips of *Citrus australasica* were successfully recovered after encapsulation and desiccation and Murcott tissue was cryopreserved using a slow freezing approach. Fine suspension cultures of mangoes were cryopreserved and viable embryos were recovered post-cryopreservation. Recent experiments have successfully replaced the toxic DMSO in the vitrification stage.

Slow growth protocol was developed for mandarin by testing varying concentration of mannitol and sorbitol. Using MS medium without growth regulator and supplemented with sucrose as carbon source slowed down growth of mandarin shoots. Slow growth protocols papaya plants *in vitro* were refined and cryopreservation of shoot tips and seeds achieved by using modified medium for the papaya micro-cutting system. Plants can be held for 8 to 12 months before transfer. The use of fructose in lieu of sucrose slows the growth considerably and allows incubation at 25°C. This is essential, as tropical species cannot be incubated at low temperatures due to tissue damage. Considerable progress has been made with experiments on papaya seed desiccation, germination and storage at different temperatures. It was found that desiccation below 15 per cent severely reduces germination percentage and that seed at any moisture content can be germinated with gibberellic acid or heat shock treatments. Seed that were stored for 1 month had germination percentages as high as 80 per cent.

The project's Second Annual Meeting was organized as planned in Hanoi, Vietnam from 8-11 December, 2004 and country coordinators had the opportunity to review and discuss their work together. Techniques and information were shared among the country coordinators.

Project FST/1999/035: The impact of changing agroforestry mosaics on catchment water yield and quality in Southeast Asia

Overseas Collaborating Countries	Indonesia, Thailand
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Collaborating Institutions	Bogor Agricultural University, Indonesia CSIRO Land and Water, Australia Chiang Mai University, Thailand Lampung University, Indonesia Forest and Nature Conservation Research and Development Centre, Indonesia Australian National University, Australia Center for Soil and Agroclimate Research, Indonesia Brawijaya University, Indonesia National University of Singapore, Singapore
Project Budget	$1,142,952
Project Duration	01/07/2002 to 30/06/2006
ACIAR Research Program Manager	Dr Russell Haines

Project background and objectives

Forest conversion in much of the uplands of Southeast Asia has resulted in a gradual loss of forest functions as the landscapes evolve into mosaics of agriculture, agroforestry and forest remnants. Inappropriate policies have frequently fuelled disputes about use of land for forest or agriculture, leading to unnecessary conflict between upland and lowland farmers. Thousands of poor communities inhabiting upland watersheds are blamed for the destruction of forests and associated hydrological functions that affect communities downstream. This has led to restrictions on land use, and there is little chance of secure land tenure for such communities.

Research is needed to gain greater understanding of the watershed hydrology in these agroforestry landscape mosaics and to use the knowledge to develop more equitable policies and practices for upland farmers. This project will test the hypothesis that some farmer-developed agroforestry mosaics are as effective as the original forest cover in protecting water yield and water quality. This project will study selected watersheds to characterise current land use and ongoing trends in land-use change, and determine their effects on filter functions and overall impacts on water quantity, seasonal effects and sediment loads. Studies will also test soil and water movement in landscape mosaics at catchment scale; quantify the trade-off between watershed functions and profitability of land use for current and possible future land-use mosaics, and explore alternative practices through farmer participation.

Project progress

Year 3 (01/07/2004-30/06/2005)

In the third year of the project we made further progress towards each of these three goals for the major research sites in Sumberjaya (Lampung, Indonesia) and Mae Chaem (northern Thailand):

Analysis of the rainfall-discharge records of the Way Besai showed that the perceived increased frequency in low flows during dry seasons is to a large extent due to the increased frequency of El Niño years in the 1990s compared to the 1970s and 1980s. The ‘buffer analysis’ that relates river flow to rainfall indicates no substantive change in the water release

characteristics of the catchment. The available rainfall-discharge data did not allow a good parameterisation of the IHACRES model, which could separate effects of rainfall vs. land use change on discharge. This was probably due to the high spatial variability of rainfall, not fully represented in the available rainfall station data and perhaps also in poor quality of the available discharge data. Two extensive field campaigns, in collaboration with local farmers and the hydro-power company were organized in February-March in order to assess sediment transport at the sub-catchment level. Variability in sediment yield between sub-catchments was smaller than the variability observed at plot level. Two small rivers were found to already have a significant sediment load during rainfall events before leaving the forest, adding extra evidence that land use might not be the dominant factor to explain erosion and sediment yield. The variation in soils within the catchment remains a key feature, with some soils 'erosive' even with full forest cover, some having a micro-aggregate structure that survives two years without soil cover without generating much erosion and others that do respond in the 'normal' way to lack of cover.

Data analysis confirmed that at plot level surface litter indeed functions as the main filter, substantially modifying the sediment concentration in overland flows. In the build up phase of a litter layer (in recently established coffee gardens), movement of litter itself is an important process that slows down the 'filter functions' – any ground vegetation that stops litter movement is important in that respect. At the landscape level footpaths and motorbike trails form channels for sediment transport that bypasses the existing filters and delivers sediment directly to the streams. A sub-project lead by Brawijaya University will collect further data on that process, complementing estimates of bank instability as source of river sediment. Field observations indicated that land slides and bank instability are a likely important sediment contributor in the area. It remains a challenge how these land slide events can be built into the existing models. Even under forest cover, (small) land slides do happen, and affect the sediment load. In the Mae Chaem catchment a typology of riparian vegetation has been developed that will be used to delineate the 'hot spot' areas of sediment delivery.

A detailed household survey in Way Besai area provided baseline data that help us understand the plot-level strategies in the context of the overall resources at household level. A new way of defining 'land use intensity' was tested. With (robusta) coffee prices only gradually increasing from their low level, diversification is still an important aspect of strategies. For Mae Chaem a summary was made of the way participatory landscape mapping can be combined with formal GIS techniques. The integrative landscape dynamics model, FALLOW, was further developed to include household-level decision making on the basis of locally acquired knowledge ('adopt and learn').

A mid-term review of the project concluded that the project is well placed to meet all the intended deliverables and that cooperation with the national partners is smooth.

Project PLIA/2000/039: Impact of migration and/or off-farm employment on roles of women and appropriate technologies in Asian and Australian mixed farming systems

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Commissioned Organisation	International Rice Research Institute, Philippines
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Collaborating Institutions	Curtin University of Technology, Australia Khon Kaen University, Thailand Cuu Long Rice Research Institute, Vietnam
Project Budget	$496,764
Project Duration	01/01/2004 to 30/06/2007
ACIAR Research Program Manager	Dr Jeff Davis

Project background and objectives

Migration from farms, either to seek off-farm employment as an income supplement or to move to areas for greater opportunities is common throughout much of Asia. Off-farm employment is seen as a way to boost income particularly in smallholder family owned farms. This may increase income but at the cost of reduced farm labour inputs and the likelihood of reduced farm output. Increasing economic pressures from trade liberalisation, globalisation and their impacts, together with constraints from environmental, disease and weed pests and water availability are increasing trends to migrate and or to work off-farm.

The wider these pressures and their affects are felt, the greater the probability of reduced farm productivity impacting on the broader economy. The main group involved in migration and increasingly off-farm employment is men. This is resulting in far-reaching changes to household structures, and in cases of long-term or permanent migration, economic and social changes. Women are increasingly being left with the task of farm management, including having to overcome production constraints, mainly from lost labour inputs of husbands, brothers and other male workers.

Such changes are also occurring in some farming communities in Australia, creating many of the same issues. Little research has been done regarding these changes, their impacts and farm management. Of particular interest are technologies that can be used to alleviate production constraints caused by labour shortages, to help women in Asian and Australian farming systems to manage farms.

The overall goal of this project is to better understand the changes occurring in rural agriculture in Asia and Australia in relation to the changing role of women as a result of off-farm employment and/or migration and the ways in which constraints and needs differ between male and female household heads. In particular, the project will identify possible strategies and technologies to help women heads to better manage farms.

Project progress

Year 1 (01/01/2004 – 31/12/2004)

This report focuses on work to determine the occurrence and extent of work-related migration and off-farm work in major rice-based or mixed farming systems in Vietnam, Thailand, the Philippines, and Australia. The first-year activities included reconnaissance, a rapid rural appraisal (RRA), and focus-group discussions (FGDs) in the Philippines, Thailand, Vietnam, and Australia. The focus of the research in Thailand, Vietnam, and the Philippines is on the out-migration of individuals of farming households, while that in Australia is on the incidence of off-farm work. Research villages in Thailand, the Philippines, and Vietnam were selected

based on criteria such as representing typical rice-growing areas under different water regimes (rainfed and irrigated) and access to labour markets (low and high). A structured guide was developed for collecting village-level information, incidence of out-migration, patterns of migration, and characteristics of migrants. FGDs were conducted with key informants to gain perceptions on labour out-migration. Migrants are defined as those individuals who have changed residence for more than 3 months and send remittances. The incidence of out-migration was calculated among farming households, males, and females.

The results of the RRA showed that the proportion of households with migrants is higher in Thailand than in the Philippines and Vietnam. A higher proportion of males than females migrate in Thailand and Vietnam and vice versa in the Philippines. The incidence of out-migration is generally higher in rainfed ecosystems than in irrigated ecosystems. Rural to urban migration is prevalent in Thailand and Vietnam because of more employment opportunities in nearby districts and provinces brought about by rapid industrialisation and better communication and transportation facilities. In the Philippines, although rural to urban migration occurs, domestic to international migration is more prevalent. In Vietnam, men work as construction workers and masons in the cities and as hired fishermen, in seafishing, and with shrimp or squid catching in other provinces. Women work in waste trading and small trading, as hired labourers in rice farming, sand boating workers, domestic helpers, and factory workers, or in other industrial areas near rural areas. In Thailand, male and female migrants work as construction workers, factory workers, and in the trading/business and service sector. In the Philippines, female migrants mainly work as domestic helpers and entertainers within the Philippines and in the Middle East, Italy, Singapore, and Hong Kong. Others work as factory workers in Taiwan, Japan, and Korea. Male migrants work in the Middle East as construction workers, drivers, operators of heavy equipment, or seamen.

FGDs revealed that low rice productivity in the rainfed areas, the small size of landholdings, the lack of regular and alternative income sources, low profitability in rice farming due to high input costs, the desire of youth to seek adventure in the cities, and as a status symbol for a household to have a migrant abroad are some of the reasons for migration. Other reasons are the availability of non-farm work because of social networks, better wages, and the attraction of better living conditions in urban areas. Wives mentioned that remittances increase their income and enable them to invest in agriculture, repay their debts, and improve their living conditions. However, when husbands are absent on a long-term basis, the women face loneliness, insecurity, and emotional stress when remittances do not come on time for children's education, farm inputs, and other household expenditures. Women take on additional responsibilities of managing the farms.

It is clear that labour out-migration and/or off-farm work are occurring in all countries involved although the rates vary. The impact of family migration on agricultural productivity, farming efficiency, household welfare, and the changing role of women will be analysed in the next phase of the study.

Concluded projects

at 30 June 2005

Bilateral

Bilateral

Project FST/1998/096: Domestication of Australian trees for reforestation and agroforestry systems in developing countries

Overseas Collaborating Countries	Global, India, Indonesia, Laos, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam
Commissioned Organisation	CSIRO Forestry and Forest Products, Australia
Project Leader	Dr John Doran Phone: 02 6281 8319 Fax: 02 6281 8312 Email: john.doran@csiro.au
Project Web Site	http://www.ffp.csiro.au/
Collaborating Institutions	Global overseas collaborators, Global
Project Budget	$2,094,461
Project Duration	01/01/2000 to 31/12/2004 (Project extended from 01/07/2004 to 31/12/2004)
ACIAR Research Program Manager	Dr Russell Haines

Project background and objectives

In many countries people now face severe shortages of wood and wood products – through physical scarcity or because access to existing forest resources is restricted by commercial interests or government policies. Inadequate fuelwood compels poor people to collect fallen leaves and twigs for fuel from plantations, thereby disrupting nutrient cycling processes and impoverishing the soil.

Overall demand for fuelwood in the developing countries is expected to increase at an annual rate of 1.1 per cent; meanwhile, forest cover is steadily declining (in continental Southeast Asia at an average rate of 1.6 per cent per year). Land degradation and other changes brought about by reduced forest cover are causing substantial social, economic and environmental problems. Remaining natural forests and plantation forests are under greater harvesting pressure.

In many developing tropical and subtropical countries Australian trees have been planted (and are still being planted) to deal with the demand for forest products. The species are popular because many of them perform well on degraded, infertile sites, can deal with wide variations in climate and grow rapidly when the water supply is good. In developing countries around the world there are now more than 13 million ha of eucalypts, 2 million ha of acacias and 1 million ha of casuarinas in plantations, with many more Australian trees in agroforestry settings or scattered plantings.

But failure to use the best germplasm, and poor matching of species to the sites and to suitable uses for the product have over time reduced the benefits of using Australian trees. This domestication of Australian trees (DAT) project helped devise strategies to create more productive and sustainable planted forests in developing countries, using carefully selected Australian tree species. The work followed on from the earlier ‘Seeds of Australian Trees’ project funded by AusAID and ACIAR.

The major project objectives were to support more effective domestication and use of Australian tree species in low-income developing countries through provision of certified seed, training, and technical advice on the domestication and best use of Australian tree and shrub species.

Project outcomes

The main components of the project were seed supply, provision of technical advice and literature, and training. Research seedlots were sent to 44 recipients in 20 countries between January and December 2004. Developing-country researchers also received 87 copies of scientific and technical publications. Courses in Sri Lanka and Vietnam trained participants in seed orchard management and seed technology for seed orchards, including seed quality issues, seed collection, processing and documentation. A training course in Guangzhou, China, introduced software and methods for analysis of advanced-generation breeding populations.

Genetic gain trials established in the Philippines, India, Sri Lanka, Thailand and Vietnam enabled researchers to compare the performance of seed collected from in-country seed orchards established and managed by DAT collaborators with the original natural provenances used to establish the orchards as well as local commercial seed sources. These trials use large plot size (typically 36-tree or 49-tree square plots) and four or more replicates, in order to accurately rank the performance of the seedlots and determine whether trees grown from the seed orchard seedlots showed significant improvement in plantation performance. Two-year performance data from the genetic gain trials in the Philippines (*Acacia mangium*, *Eucalyptus urophylla*), Thailand (*E. camaldulensis*, two locations) and Vietnam (*A. auriculiformis*, *A. mangium*), and one-year performance data from Sri Lanka (*E. grandis*) were collated and analysed by partner organisations.

In summary, the studies found excellent performance of the orchard seedlots relative to natural provenance and commercial controls. The orchard seedlots were ranked best or close to best for height and diameter growth in all of these trials, and also displayed above-average survival. Treatment differences were statistically significant for most of the trials. For *A. mangium* in the Philippines the orchard seedlot had more than twice the 2-year conical stem volume of a locally used Mindanao land race of *A. mangium*, while in Vietnam the orchard *A. auriculiformis* had 38 per cent greater 2-year conical stem volume than the local commercial seed source, and significantly superior branching and stem straightness. In both these cases the orchard seedlots also significantly outperformed the natural-provenance controls, demonstrating that significant genetic improvement had been achieved in the orchards.

Partner research organisations in the collaborating countries are already using these results to promote the use of superior orchard seed over other local alternatives. Already in India small unreplicated demonstration trials of the orchard seedlots of *E. camaldulensis* and local alternative seed sources established on plantation company lands have led to strong commercial demand for seed from the DAT orchards.

Paclobutrazol treatment of eucalypt seed orchards in India, carried out during the project, led to substantial increases in flowering and seed production, and it is anticipated that this treatment will be used operationally to boost seed production of low-yielding species such as *E. tereticornis*. A new seed orchard of *E. tereticornis* was successfully established in Sri Lanka under the project, while in Vietnam clonal seed orchards of *A. auriculiformis*, *A. mangium* and *E. camaldulensis* were established in three locations across the country. The best 30 or so clones of each species, propagated from progeny trials, were established in a clone bank for intensive control-pollinated breeding, using clone bank technology transferred from CSIRO via the DAT project.

Project staff from CSIRO and from collaborating countries including China, Cambodia, India, Indonesia, Laos, Thailand, the Philippines and Vietnam attended a two-day meeting in Bangkok to review progress with domestication of key Australian species and plan for future collaboration after the conclusion of the project.

Project LWR/1997/150: Salinity management in southeastern Australia, northeastern Thailand and Lao PDR

Overseas Collaborating Countries	Laos, Thailand
Commissioned Organisation	University of Technology, National Centre for Groundwater Management, Australia
Project Leader	Dr William Milne-Home Phone: 02 9514 1984 Fax: 02 9514 1985 Email: william.milne-home@uts.edu.au
Project Web Site	http://www.abc.net.au/rn/science/ss/features/suitcase/thai_laos/default.htm
Collaborating Institutions	Hall Resource Economic Modelling, Australia Ministry of Agriculture and Forestry, Laos Khon Kaen University, Thailand Land Development Department, Thailand Royal Forest Department, Thailand
Project Budget	$743,496
Project Duration	01/01/2001 to 31/03/2005 (Project extended from 01/01/2004 to 31/03/2005)
ACIAR Research Program Manager	Dr Ian Willett

Project background and objectives

Salinity is a major cause of land and water degradation and economic losses in Thailand and Australia. In Australia dryland salinity is a national problem, affecting more than 2.3 million ha with a further 12.3 million at risk. In northeastern Thailand it is estimated that an area of 6 million hectares (or 34 per cent of arable land) are affected by salt, and the problem appears to be escalating. In Lao PDR it is of minor importance, but has the potential of becoming equally serious.

The reason for the spread of salinisation is the large-scale clearing of trees, leading to gradual increase in surface soil salinity and stream salt loads. The main difference between the dryland salinity in Australia and Thailand is the source of salt. In Australia the salt is stored in a metastable state in the soil until water tables rise and bring the dissolved salt to the surface. In Thailand the source of salt is the dissolution of rock salt in the Mahasarakham Formation that underlies much of north eastern Thailand and parts of Lao PDR.

The economic implications of soil salinisation are potentially very large, as seen in parts of Australia and Thailand. Yields of rice and economic returns from salt-affected soils are about one third of those achieved in unaffected areas. Rising salt can affect bores and drinking water quality.

In Lao PDR there are signs of salinity to the northeast of Vientiane and around Savannakhet. A low-technology salt-making industry is found in both these areas, as in northeastern Thailand. The research studied how salinity could be aggravated by irrigation and deforestation plans in Lao PDR. The project sought to contribute to agricultural sustainability of salinised land in parts of northeastern Thailand, Lao PDR and southeastern Australia.

Project outcomes

New modelling approaches were applied in Thailand following the identification of limitations in existing socioeconomic and biophysical models. The existing SMAC model was restructured by updating the hydrogeological and socioeconomic modules to include an agroforestry component. Application of the new model to the Upper Macquarie Valley (NSW) successfully assessed the potential role of agroforestry as an alternative land use and salinity

management tool. Modelling and optimisation results were then transferred to stakeholders including Landcare and DIPNR.

SMAC was rewritten as an EXCEL™ spreadsheet for Thai conditions as a catchment model capable of optimising land use for maximising economic return and minimising land salinisation. This Isaan Catchment Hydrological and Agricultural Model (ICHAM) was transferred to the Land Development Department (LDD) of Thailand whose staff members are further developing the user interface to include Thai language and to be compatible with models already in use. Restructuring the model format has increased the likelihood of user uptake. The joint development of ICHAM introduced new research techniques to Thai project scientists.

Researchers took field measurements of tree sapflow and compiled tree water use datasets (TWUs) to calculate the water consumption of various tree species in Australia and Thailand. These measurements were complemented at each site with data on rainfall, temperature, soil moisture and groundwater levels for statistical correlation with the TWUs. TWUs were compiled for *Casuarina* spp., *Eucalyptus camaldulensis*, *Acacia ampliceps* and *Azadirachta indica* (Neem) and others.

Water use by salt tolerant grasses, including *Sporobolus virginicus* (commonly known as Dixie grass) was also measured at a site near Khorat. These data have been used in other LDD projects rehabilitating saline land. Other sites in Khorat province are being successfully revegetated using selected species to manage local recharge-discharge areas. Data collected on water consumption by vegetation helped in compiling realistic estimates of water balance components and assisted the model development.

Knowledge of salinity processes in Australia and Thailand allowed a scoping of the salinity risk from irrigation expansion in areas of Lao PDR similar to northeast Thailand. Research focused on identifying the potential for a salinity problem by outlining the physical drivers and conceptual processes whilst increasing awareness amongst stakeholders. Initially, efforts focused on information review and data collection and a significant GIS database was established to identify the potential salinity risk areas, based on irrigation developments and land use change. Two key risk areas were identified in Vientiane and Savannakhet Provinces where salinity was likely to be derived from the underlying evaporite (rocksalt) formations, as in neighbouring Isaan, Thailand.

An investigation of the Champone District in Savannakhet showed that the active groundwater flow systems occur in the surficial, alluvial deposits of the Champone River and the catchment-rim silty gravel terraces. These deposits overlay a 40 m thick claystone, possibly fractured in places, which is above the rocksalt. Brine from the rocksalt, pumped locally for small-scale salt making, appears to be the source of the salinity. Groundwater modelling suggests that the rate of supply is extremely low, but proposed irrigation developments should avoid inadvertent augmentation of shallow groundwater systems such that flow comes into contact with the underlying claystone. If this happens there is potential for mobilisation and transport of the salt, leading to soil salinisation.

The research has successfully defined the salinity processes, enabling the identification of those land-use practices driving salinity. Given the wide scale of potential land salinisation and the rapid pace of agricultural development in the region, significant effort was made to increase awareness of salinity amongst government departments at both the central and regional scale. Numerous extension activities were conducted including meetings, workshops and study tours, introducing government officers to the processes causing salinity and highlighting the potential economic, social and environmental impacts. Particular success was noted through the involvement of Thai scientists and demonstration of the real impact experienced in neighbouring Thailand.

Project LWR/1998/124: Development of technologies to alleviate soil acidification in legume-based production systems in the tropics of Asia and Australia

Overseas Collaborating Countries	China, Thailand
Commissioned Organisation	CSIRO Land and Water, Davis Laboratory, Australia
Project Leader	Ms Suzanne Berthelsen Phone: (07) 4753-8534 Fax: (07) 4753-8600 Email: Suzanne.Berthelsen@csiro.au
Collaborating Institutions	Queensland Department of Natural Resources and Mines, Australia Chinese Academy of Tropical Agricultural Science, China Khon Kaen University, Thailand
Project Budget	$712,810
Project Duration	01/07/2000 to 30/06/2005 (Project extended from 01/07/2004 to 30/06/2005)
ACIAR Research Program Manager	Dr Ian Willett

Project background and objectives

Legumes are widely used in farming systems to improve soil fertility and organic matter accretion through their nitrogen fixation, and to provide protein for human and animal consumption. Some legumes are crops (for example, soybean and peanut), while others are pasture plants (such as *Stylosanthes*) or trees (such as *Leucaena*). *Stylosanthes*, or Stylo, has proved to be an ideal, cheap method of improving the quality of native pastures in Asia, Africa, South America and northern Australia. It adapts well to low-fertility soils and tolerates a range of climate types.

The importance of introduced legumes such as these for increasing the productivity of tropical agricultural systems has long been recognised. However, it is now clear that legumes make the soil more acid. Recent research has shown that acidification has occurred in pastures in Australia's semi-arid tropics following the introduction of *Stylosanthes*. This is also occurring in northeast Thailand, southern China and southern India, at similar rates to those measured in northern Australia. Acidification of soils affects the availability of nutrients to plant roots, by altering the balance of ions.

The soils that have shown the greatest degree of acidification are light-textured, and are characterised by their poor fertility, and inherently small ability to buffer pH changes. Such soils are becoming increasingly important agriculturally (and hence economically). If the soil's organic matter were increased, this would provide greater buffering capacity. Acidity can also be remedied by applying a base, but given the large areas and depth to which the acidity occurs, this would be impractical.

Research is therefore needed to develop production systems that minimise soil acidification and its negative effects. This project will carry out lab and field-based trials in China, Thailand and Australia to help with this. The main objective of this project was to develop new methods to prevent or limit the damaging process of soil acidification.

Project outcomes

- demonstrated that nitrate-fertilised, deep-rooted grasses can neutralise soil acidity at depth. This finding is particularly significant because neutralisation to depth is rarely possible with conventional approaches using lime.
- demonstrated that applications of materials such as bentonite can be used to restore fertility to degraded, sandy soils in NE Thailand.
- demonstrated that stylo dominance in pastures can be controlled by burning.

Projects under development

at 30 June 2005

Bilateral	
AH/2004/075	Improving the benefits of small-scale family poultry farming in rural and peri-urban communities in Cambodia
AH/2005/086	Improved control and surveillance of diseases of livestock in Laos
CIM/2004/070	Improving mungbean, soybean and peanut production in Lao PDR and Cambodia
FIS/2005/078	Culture based and capture fisheries development and management in reservoirs in Laos
FST/2002/112	Domestication of Meliaceae species in Southeast Asia and Australia, particularly management of the problem of Hypsipyla robusta attack
FST/2004/056	Enhancing agroforestry systems involving non-timber forest products in Laos
FST/2004/057	Optimising production of timber and non-timber forest products in Laos agroforestry systems
LPS/2003/008	Enhancing beef production in Cambodia through better nutrition
PHT/2003/045	Improvement of vegetable production and postharvest management systems in Cambodia and Australia
Multilateral	
LPS/2004/046	Forage legumes for supplementing village pigs in Lao PDR
PLIA/2003/063	Increasing the effective use of livestock research for development in SE Asia

ACIAR publications

This list is a selection of titles from ACIAR's range of scientific publications that are relevant to the agricultural research and development sector of Cambodia, Lao PDR and Thailand. Hard copies are available by emailing comms@aciar.gov.au. Publications may also be downloaded from ACIAR's website, www.aciar.gov.au

Monographs

51 Biological Control of Insect Pests: Southeast Asian Prospects
53 Field Experiments with Forages
58 Understanding Animal Health in Southeast Asia: Advances in Collection, Management and Use of Animal Health Information
97 Effects of Globalisation and Economic Development on the Asian Livestock Sector
98 Domestication of *Chukrasia**
99 Developing Agricultural Solutions with Smallholder Farmers: How to Get Started with Participatory Approaches
100 Field Methods for Rodent Studies in Asia and the Indo-Pacific
111 High-yielding Anthracnose-Resistant *Stylosanthes* for Agricultural Systems
113 Worm Control for Small Ruminants in Tropical Asia
114 Diversity and Management of Phytophthora in Southeast Asia
118 Integrating Knowledge for River Basin Management – Progress in Northern Thailand
119 Guidelines for Surveillance for Plant Pests in Asia and the Pacific

Proceedings

18 Food Legume Improvement for Asian Farming Systems
29 Sulfur Fertiliser Policy for Lowland and Upland Cropping Systems in Indonesia
33 Sustainable Agriculture on Marginal Uplands of Southeast Asia
42 Productive Use of Saline Lands
50 Postharvest Handling of Tropical Fruit
51 Foot-and-Mouth Disease in Southeast Asia
57 *Leucaena* – Opportunities and Limitations
61 Agricultural Impacts on Groundwater Quality
77 Breeding Strategies for Rainfed Lowland Rice in Drought-prone Environments
81 Disease Control and Storage Life Extension of Fruit
87 Upland Farming Systems in the Lao PDR: Problems and Opportunities for Livestock
90 Towards Sustainable Shrimp Culture in Thailand and the Region
94 Classical Swine Fever and Emerging Diseases in Southeast Asia
97 Hypsipyla Shoot Borers in *Meliaceae*
98 Reservoir and Culture-based Fisheries: Biology and Management
101 Increased Lowland Rice Production in the Mekong Region
104 Agrochemical Pollution of Water Resources
108 Development Strategies for Genetic Evaluation for Beef Production in Developing Countries
111 Eucalypts in Asia
116 Water in Agriculture
119 Agriproduct Supply Chain Management in Developing Countries

Technical reports

16 Mineral Nutrition of Food Legumes in Thailand
30 A Review of the Biology and Management of Rodent Pests in Southeast Asia
31 *Styrax tonkinesis*: Taxonomy, Ecology, Silviculture and Uses

47 Coastal Shrimp Aquaculture in Thailand: Key Issues for Research
49 *Chukrasia*: Biology, Cultivation and Utilisation
52 Rice–Shrimp Farming in the Mekong Delta: Biophysical and Socioeconomic Issues
56 Feeds and Feeding for Inland Aquaculture in Mekong Region Countries
61 Production Technologies for Low-chill Temperate Fruit

ACIAR Working Papers

25 A Preliminary Evaluation of 54 ACIAR-supported Projects in Thailand (1983–1995)
38 Impact Assessment of Forty-nine Thailand/Australia Collaborative Projects Funded by ACIAR during 1983–1995
41 Developing Forage Technologies with Smallholder Farmers: How to monitor and evaluate impacts
53 Priorities for Pig Research in Southeast Asia and the Pacific to 2010
54 Mud Crab Aquaculture Aquaculture in Australia and Southeast Asia
56 Agricultural Research and Poverty Alleviation: Some International Perspectives
58 Scaling Out Impacts: A Study of Three Methods for Introducing Forage Technologies to Villages in Lao PDR