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Impact Assessment of Twenty-one ACIAR-supported Projects Based at the University of the Philippines, Los Baños (1983–1995)

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Australian Centre for International Agricultural Research

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Abbreviations

AAFARR	Australian–Asian Fibrous Agricultural Residues Research Network
ACIAR	Australian Centre for International Agricultural Research
AIDAB	Australian International Development Assistance Bureau (now AusAID)
APSRU	Australian Agricultural Production Systems Research Unit
AVRDC	Asian Vegetable Research and Development Center
CS	Crop Sciences
DENR	Department of the Environment and Natural Resources, Philippines
DOA	Department of Agriculture
MARDI	Malaysian Agricultural Research and Development Institute
NAREA	National Agricultural Research and Extension Agenda
NEDA	National Economic Development Authority
NSW DOA	New South Wales Department of Agriculture
PCA	Philippine Coconut Authority
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PCARRD	Philippine Council for Agriculture Forestry and Natural Resources Research and Development
PHTRC	Postharvest Training and Research Center, UPLB
QDPI	Queensland Department of Primary Industries
QFRI	Queensland Forestry Research Institute
UNDP	United Nations Development Program
UPLB	University of the Philippines, Los Baños
VISCA	Visayas State College of Agriculture

Contents

1. The numbers in brackets are ACIAR project numbers. Italicised project numbers indicate projects in progress at the time of this study

Summary

This paper discusses project level evaluations of twenty-one ACIAR-supported projects based at the University of the Philippines at Los Baños (UPLB) funded between 1983 and 1995.

The projects fall into the following ACIAR research programs:

- agricultural and natural resources economics;
- postharvest technology;
- animal sciences;
- land and water resources;
- forestry; and
- crop sciences.

The paper estimates the research costs, the total benefits, and the internal rates of return associated with the twenty-one projects. The paper discusses the different methodologies used, the data sources, and the key assumptions made in the estimations. Thirteen of the analyses are ex-post evaluations of completed projects, and eight are ex-ante analyses of projects in progress. The paper takes into account all sources of funding for the research, and it estimates returns to the funds jointly invested in the project by ACIAR, the Australian commissioned organisations and ACIAR's partner countries.

Acknowledgments

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Introduction

The purpose of this paper is to present results from the evaluation of twenty-one ACIAR-supported collaborative research projects involving research groups at the University of the Philippines at Los Baños (UPLB) and a range of Australian research institutions. The paper is a product of collaborative work (from 1994 to 1997) in the area of project level evaluation between the College of Economics and Management at the University and ACIAR's Economic Evaluation Unit.

The research evaluation work started in 1994 with the following objectives:

1. Develop an overview of the impact of projects with research groups at UPLB supported by ACIAR, and include in this a review of all past project level research evaluation studies for Philippine agriculture.
2. Undertake detailed project-level evaluations of the impact (realised and potential) of completed and continuing projects with research groups at UPLB, and estimate the welfare impacts of the projects on all groups in the Philippines, including any environmental impacts, and impacts on other countries in the region if applicable.
3. Undertake project development assessments for new projects developed with research groups at UPLB during the activity period.
4. Develop systematic databases of the information collected to support the project evaluations, and include in these databases any industry structure descriptions which might be important to the projects.
5. Provide training in the area of research evaluation methods and practices.

This paper summarises the results from analyses under objectives 1, 2 and 3. The data collected under objective 4 have been used in the estimation of research benefits. Objective 5 was achieved through a training course for 30 participants (from Philippines, India, Thailand, and Australia) held from 28 September to 5 October 1996, at the University of Philippines, Los Baños.

The next four sections of the paper cover the following:

- a summary of the twenty-one projects discussed in this paper;
- the methodologies used in estimating research benefits;
- the benefits from research and the parameter values used in the estimation of benefits; and
- conclusions.

A summary of twenty-one ACIAR-supported projects

Table 1 summarises some of the aspects of the twenty-one projects with the UPLB research groups. The table shows the collaborating research groups within UPLB, a list of the other countries involved in the projects and if the project is completed or on-going. Appendix A provides a brief description of each project. Figure 1 shows a map of the Philippines and some of the locations where research was carried out in that country.

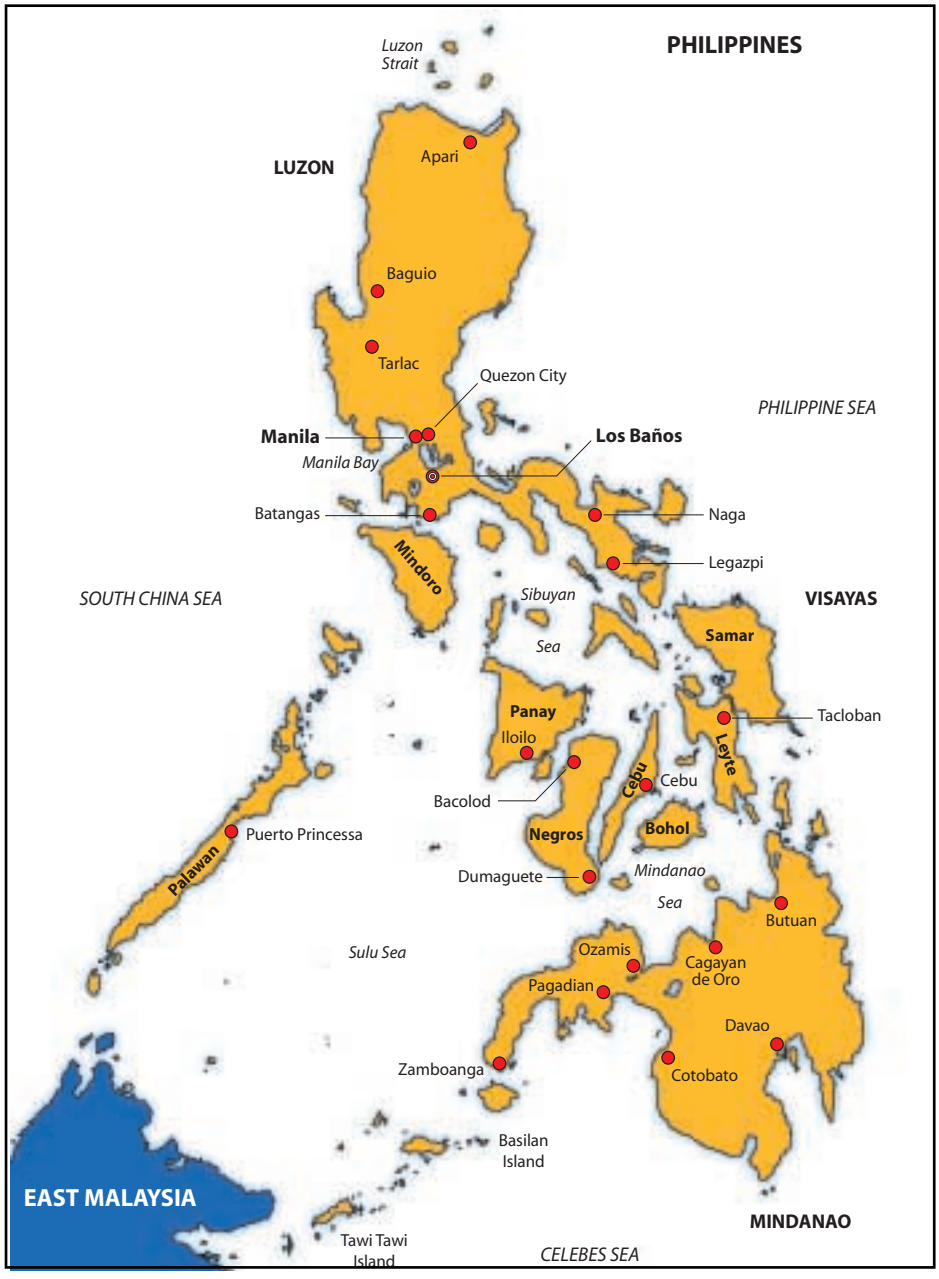

Figure 1. Map of the Philippines showing research locations

Table 1. Overview of UPLB-based collaborative projects supported by ACIAR (1983–1995)

Count	Project	Title	Australian institution	Philippine institution	Philippine research group(s)	Third party countries	Completion date
1	EFS/1986/024	Research priorities for Philippines agriculture	ANU	DOA, PCARRD, PCAMRD, UPLB	Department of Economics	None	1991
2	ANRE1/1991/009	The world market for coconut production: an economic analysis from the perspective of the Philippines	UNSW	UPLB, NEDA	Department of Economics	Indonesia	1995
3	PHT/1983/055	Postharvest physiology and technology of bananas and application to some other tropical fruits in Southeast Asia		UPLB	PHTRC, Department of Horticulture	Thailand	1986
4	PHT/1983/056	Physiological, chemical and storage characteristics of mangoes and some other tropical fruits in Southeast Asia		UPLB	PHTRC, Department of Horticulture	Thailand Malaysia	1987
5	PHT/1990/051	Development of heat systems for quarantine disinfestation in tropical fruit	QDPI	UPLB, DOA	PHTRC, Department of Horticulture	Thailand	1994
6	AS1/1983/073	Utilisation of fibrous agricultural residues as ruminant feeds	University of Melbourne	UPLB	Institute of Animal Science	Thailand	1987
7	AS2/1985/015	Evaluation of different buffalo genotypes for draught, meat and milk production	CSIRO	UPLB	Institute of Animal Science	Sri Lanka Malaysia Thailand Indonesia	1992
8	SWL/1985/051	The management of soil erosion for sustained crop production	QDPI	UPLB, VISCA	Department of Soil Science	Malaysia Thailand	1992
9	LWR1/1992/001	Sustainable cropping systems for tropical steeplands	Griffith University	UPLB, VISCA	Department of Soil Science	Malaysia Thailand	1996
10	PN/1985/074	Ecology of rhizobium nodulating grain legumes in the Philippines	ANU	UPLB	Department of Soil Science	None	1987
11	PN/1987/031A	Biological nitrogen fixation in food legume production systems in the Philippines	University of QLD	VISCA, UPLB	Department of Soil Science/ College of Forestry	None	1990
12	PN/1985/073	Ecology of rhizobium nodulating tree legumes	ANU	UPLB	Department of Soil Science	None	1987
13	PN/1987/031A	Biological nitrogen fixation in food legume production systems in the Philippines	University of QLD	VISCA, UPLB	Department of Soil Science/ College of Forestry	None	1990
14	FST/1992/008	Tree establishment technologies in the Philippines	University of QLD	UPLB, DENR	College of Forestry/ National Institute of Biotechnology & Applied Microbiology	None	1996
15	*FST/1996/110*	Tree production technologies for Philippines and Australia	QFRI	UPLB, VISCA, PCARRD			ongoing
16	*CS1/1990/015*	New approaches to the control of bacterial wilt (*Pseudomonas solanacearum*) in tomato and other vegetable and crop plants	Montech	UPLB	Institute of Plant Breeding	Indonesia	1995

Table 1. (cont'd) Overview of UPLB-based collaborative projects supported by ACIAR (1983–1995)

Count	Project	Title	Australian institution	Philippine institution	Philippine research group(s)	Third party countries	Completion date
17	*CS1/1994/052*	Control of bacterial wilt (*Pseudomonas solanacearum*) by agricultural biotechnology	University of Adelaide	UPLB	Institute of Plant Breeding	Indonesia	ongoing
18	*CS1/1996/231*	Control of bacterial wilt (*Pseudomonas solanacearum*) by agricultural biotechnology	Montech		Institute of Plant Breeding	Indonesia Taiwan	ongoing
19	*CS1/1991/007*	Control of papaya ringspot virus in the Philippines by development of PRSV resistant hybrids	QDPI	UPLB	Institute of Plant Breeding	None	1996
20	*CS2/1991/010*	Biological control of *Chromolaena odorata* in Indonesia and the Philippines	NT Dept of Primary Ind & Fisheries	UPLB, PCA	National Crop Protection Centre	Indonesia	1995
21	*CS2/1996/091*	Biological control of *Chromolaena odorata* in Indonesia, Papua New Guinea and the Philippines	PWCNT	PCA		Indonesia Papua New Guinea	ongoing

Notes: Italicised project numbers indicate projects in progress at the time of this study. For acronyms, see the list of abbreviations at the beginning of the paper.

The methodologies used in estimating research benefits

To estimate benefits from the twenty-one projects the paper uses four main approaches:

- The 'value of information' model as proposed in Lindner (1987) is used to estimate benefits from project EFS/1986/024;
- The waste reducing postharvest research as proposed by Davis (1994) is used to estimate benefits from projects PHT/1983/055 and PHT/1983/056;
- A generalised open-economy model developed in Davis and Lubulwa (1994) is used to estimate the benefits from improved access to overseas markets not accessible before research under PHT/1990/051;
- The generalised cost-reduction model is used to estimate benefits from the remainder of the projects.

Each of these models is discussed briefly below.

Lindner's 'value of information' model

Lindner (1987) suggested that, as for any other form of research, the criterion for investing in social science research should be that the expected net present value, E[NPV], is greater than zero, with

$$E\left[NPV\right] = \sum_{t=1}^{T}\left(-C_t + \upsilon_t * \mu_t * G_t\right)\left(1+i\right)^{-t} \qquad (1)$$

where:

t denotes time. T is the planning horizon. Lindner (1987) had $T = \infty$. In this paper, $T = 30$;
i is a discount factor;
C_t is the cost of research at time t;
G_t is the potential gross annual research benefit for agricultural commodity j, at time t, $G_j = s*P_j*Q_j$ where P_j is the price of commodity j, Qj is the quantity produced of commodity j, and s is a constant, $0 < s < 1$. The constant s is used to estimate the information value of social science research results to decision-makers. G_j represents the combined cost of uncertainty and risk associated with making decisions with imperfect knowledge. Gj is smaller, the smaller the value of the industry, and the higher the quality of information available when decisions affecting commodity j are made;
v is the probability that research output is available by year t;
u is the proportionate level of adoption of research output by year t.

Waste reducing postharvest research model

Davis (1994) developed a model which is used in the analysis of benefits of the two tropical fruit projects (PHT/1983/055 and PHT/1983/056). The core of the model involves the following relationships:

Farm level supply:

$$Q_{fh} = a_h + b_h P_{fh} \qquad (2)$$

where:

Q_{fh} is the quantity of a commodity produced at the farm level in country h;
P_{fh} is the farmgate price of the commodity in country h; and
a_h and $b_h$are the intercept and slope of the supply curve in country h.

Farm to retail production linkage:

$$Q_{rsh} = d_h Q_{fh} \qquad (3)$$

where:

Q_{rsh} is the quantity supplied at the retail level; and
δ_h is farm to retail level conversion factor and is the rate at which the farm level quantity is converted to the retail quantity in country h. The wastage rate of the commodity from the farm level to retail is then $(1 - \delta_h)$ where $0 < \delta_h < 1$. For example, if 30% of the farm product is lost between the farm gate and

consumer purchases the wastage rate is 0.3 and therefore $\delta_h = 0.7$.

Farm to retail price linkage:

$$P_{fh} = \delta P_{rh} - M_h \quad (4)$$

where:

P_{rh} is the retail level price; and
M_h is the postharvest cost per unit of farm level output produced.

Retail sector supply:

$$Q_{rsh} = \delta_h[a_h + b_h(\delta_h P_{rh} - M_h)] \quad (5)$$

Retail demand:

$$Q_{rdh} = c_h - d_h P_{rh} \quad (6)$$

where:

c_h and d_h are the intercept and slope of the demand curve in country h.

In Davis (1994), a technology which reduces wastage may be associated with additional postharvest costs, and lead to a shift in the retail level supply. The retail price of the agricultural commodity falls, the quantity consumed increases, generating an increase in consumer surplus. Producers may gain or lose, depending on how the adoption of the postharvest technology impacts on farmgate prices and quantities produced.

Benefits from improved access to overseas markets not accessible before research

The generalised open-economy model developed in Davis and Lubulwa (1994) is used to estimate the benefits from improved access to overseas markets after research under PHT/1990/051.

Improved access is modelled as a special case of commodity wastage, where the analysis focuses on the exportable surplus of the commodity. When there are quarantine barriers preventing exportable produce reaching overseas markets, this is equivalent to 100% wastage of the exportable surplus. Research leading to the surmounting of these quarantine barriers reduces wastage to zero.

Generalised unit cost reduction model

In the rest of the paper, use is made of a generalised unit cost reduction model as developed by Davis et al. (1987). In this model, a cost reduction per ton of a commodity is estimated by comparing the cost of production 'before research' with the cost of production 'after research' for a representative farm. This estimate of the impact of research takes into account the farmers economic cost of inputs. The concept of cost can be broadened to include:

- on-site ecological costs;
- off-site ecological costs imposed by the farmer to third parties; and
- the costs to the environment (due to the use of methyl bromide, for example) associated with farmer practices.

With this change it is possible to extend the range of possible research impacts that can be examined under the framework proposed by Davis et al. (1987). The generalised unit cost reduction model is used to estimate benefits from 17 of the ACIAR-supported projects discussed in this paper.

Estimation of impact

In all the evaluations, confidential end-of-project review documents have been the first source of information about the type and magnitude of impacts from the projects. The reviewers' main responsibility is to assess whether the research objectives have been achieved. Projects which fail to meet their agreed objectives rarely lead to major impacts. Technical success is usually a first prerequisite, though not a sufficient one, of possible impact from research.

Unfortunately, the end-of-project reviews are often made too soon after the completion of research. The timing of the reviews to judge the technical success of projects is appropriate, but may not reliably assess the impacts of the projects. To remedy this, the evaluation team has held interviews with project leaders of completed projects and with scientists in Australia and the Philippines, to obtain more recent assessments of project impacts. In addition, members of the evaluation team at UPLB have interviewed selected farmers to establish whether various technologies have been adopted at farm level and the nature of the farm-level impacts of ACIAR-supported research.

Estimation of adoption paths

Without adoption of research results, the economic impacts of a research project are likely to be zero. The adoption of agricultural technology is often a slow process. Thus, the estimation of benefits from agricultural research requires prediction of an adoption path for the technology. The estimates of adoption paths used in this paper are based on data largely solicited from project scientists. The data were checked against other sources and, in the case of the Philippines, it was validated through farm visits by members of the evaluation team. The data were supplied in response to the following questions:

- State the year in which the technology from an ACIAR-supported project was first adopted. In the case of an ongoing project, estimate the year (in the future) when the intended users are likely to start using the technology.
- In the year adoption begins, estimate the proportion of targeted farmers likely to start using the technology.
- From your experience with similar technologies, what is likely to be the ceiling or maximum adoption level for this technology?
- How many years is it likely to take from the year of first adoption to reach the ceiling or maximum level of adoption?

Responses to these questions are summarised in Appendix B (Tables B1 to B5). These data are used to approximate the adoption path. In this path, adoption is zero up to the year of first adoption. Between the year of first adoption and the ceiling adoption, adoption levels increase linearly. From the year in which adoption reaches the ceiling, adoption levels are constant to year 30.

Attribution of benefits

A problem common to all the evaluations in this paper relates to how much of the benefit stream should be attributed to ACIAR-supported projects. There are two aspects to this problem:

- ACIAR project team versus earlier national research efforts

In many cases, an ACIAR project adds value to research which had been in progress before the ACIAR project. Sometimes the ACIAR project is a critical step in the process of delivering a particular technology. Often, additional research is carried out after an ACIAR project, to fine-tune the technology for local end users. The relative shares in total research time could be used to estimate relative contributions to the benefits from research. However, different organisations' time contributions have to be adjusted for quality aspects of the inputs. Thus, it is impossible to determine the relative intellectual contributions to the technology delivered from the different research efforts.

- ACIAR funding versus funds from other donor agencies

In many cases ACIAR co-funds research activities in the different countries. The evaluation of a technology should cover all costs of research incurred before the ACIAR project to the time the research results are delivered to end users. Unfortunately, these costs are not readily available. It is not clear for many of the twenty-one projects in this paper that were co-funded, that the technology would not have been produced with funds from some other agency. In some cases, the ACIAR project may have enabled the delivery of a technology earlier than would have been possible without the project. However, the estimate of the extent of speeding up of technology is subjective and varies depending on the respondent.

In these evaluations, the strategy has been to estimate the benefits from the technology from ACIAR-supported research, without resolving the attribution issue.

Estimates of benefits from ACIAR-supported research

This section summarises the estimated benefits from twenty-one ACIAR-supported research projects. The results in Table 2 (page 24) are presented for three main scenarios. The base case represents, in the view of the evaluation team, the most likely outcome of the different projects, in terms of total benefits and rates of returns. The data describing the base-case scenarios are listed in Appendix B. On either side of the base case are results from two sensitivity analyses – one for low benefits and another where a higher level of benefits could be achieved compared with the base case. The sensitivity analyses are described in the text.

The benefits and research costs are discounted at 8% per annum. The estimates are in 1994 dollars: 1994 was selected as the base year because that is the most recent year for which FAO data on production and consumption are available on a consistent basis for the whole world.

The estimates in Table 2 assume a time horizon of 30 years. Given that ACIAR was established in 1982, the choice of a 30-year time horizon means that the bulk of benefits in Table 2 are predicted benefits. However, an attempt has been made to incorporate in these predictions as much as is known about current levels of adoption for the different technologies.

Table 3 gives the distribution of estimated benefits by country for the base-case scenario.

1. Research priorities for Philippines agriculture (EFS/ 1986/024)

According to the reviewers of EFS/1986/024 (ACIAR 1990), economic benefits of this project can stem from a number of sources including:

1. a direct benefit in the form of a contribution to improved allocation of existing resources (an efficiency gain) resulting from use of the decision-support system;
2. an indirect benefit from an increase in the stock of research human capital through training of staff;
3. heightened awareness of economic issues in the process of allocating resources;
4. institutional changes induced by the project results; and
5. an increase in the annual flow of research funding.

At the time of the review, there was no evidence of benefits from 3–5 above. However, the budget for funding of agricultural research in the Philippines has increased since the review of the project (Dr William Dar, PCARRD, pers. comm., 1997). The reviewers commented favourably on the training impacts (2) of the project, through formal training and involvement in the project of junior staff. This investment in human capital was expected to form a significant part of the project's residual impact. Table 2 summarises these impacts.

At the time of the review of the project, only very preliminary results had emerged in the case of the Philippines, and it was premature to have expected to observe direct benefits (1) stemming from changes in the allocations of research funding. The reviewers commented that:

> The potential may well exist for direct benefits to accrue in the Philippines, but those gains will be long term. Not only does the project have to produce credible results, and have these adopted by the decision-makers, but then one must wait for the results of the research investment itself to emerge and be adopted before real benefits flow. In the best of all circumstances this could take a minimum of 5 years from now.

This paper makes preliminary estimates of benefits achieved from funding agricultural research on different commodities in proportion to the commodity's contribution to gross national benefits. Data on production were obtained from FAO (1994). The expected value of perfect information is estimated from Bantilan and Lantican (1991), Dar et al. (1994), and Davis and Ryan (forthcoming).

These documents provide, for the following 24 commodities, estimates of benefits to Philippines from agricultural research that leads to a 5% cost saving in production:

Rice	Sugarcane	Corn	Chicken	Hog
Banana	Coffee	Round scad	Coconut	Pineapple
Tobacco	Tuna	Milkfish	Garlic	Prawn
Carabao	Cattle	Tomato	Tilapia	
Cassava	Sweet potato	Cocoa	Cotton	
Soybean				

Benefits arise because the project's set of priorities by agricultural commodity significantly differed from the priorities existing before research. The priorities suggested by the project assume that Philippine research funding agencies aimed at maximising national economic welfare. Dar et al. (1994) discuss the difference between the research priorities before and after research.

Table 2 shows estimates for three scenarios, as follows:

The base case

Under the base case, the information value of social science research results to decision-makers is assumed to be about 0.001 or 0.1% of the value of the different industries.

The level of adoption used in Lindner (1987) was 100%. However, in the case of EFS/1986/024, the improved set of priorities covered only 24 of 40 commodities funded in the Philippines. This was corrected for by using a ceiling adoption less than 100%. In the analysis, we assume a ceiling adoption of 10%. This low adoption level is used because the reviewers of this project (ACIAR 1990) had several reservations about the decision-support system proposed under Project EFS/1986/024. These included the following:

- The approach is commodity based and cannot directly handle research that is directed to disciplines or inputs.
- It is best suited to production systems where a single commodity dominates; more complex integrated farming systems are less amenable to the approach.
- To date, the work has been focused on production aspects of the commodity at the farm level; innovations in postharvest technology have not been addressed.
- There is an issue concerning the role of the public versus private sectors. By establishing a ranking of relative research priorities one cannot automatically infer that the public support for research should be allocated accordingly.
- With a few exceptions there may be little need for a system that incorporates endogenously determined world prices; almost all countries are small price takers in international markets.
- It is not clear that spillover effects between regions in a country are of sufficient importance for most commodities to warrant the intensive process of eliciting the parameter estimates that the system requires.
- The complexity of the resulting system could impede its adoption. There are, at most, one or two people[2] in the country who understand the system, and research managers will naturally be reluctant to accept results unless they can develop a greater appreciation of the results and the methods associated with them.
- The value of the system for setting priorities at the national level may have been over-estimated. While it is true that the system can offer some broad guidelines about the relative priorities, at least for a limited number of the major commodities, this will not necessarily become an ongoing part of the process of research management. Once the list has been produced, then it is not clear what the value would be from regularly updating it.

Since this evaluation was undertaken after the completion of the project, the probability that research output is available by year t is 1.

Table B1 in Appendix B shows the other values used in these preliminary estimates.

The low benefits

This scenario is very similar to the base case. Under the low benefits, the information value of social science research results to decision-makers is equal to 0.0005 of the value of the industry affected by research – that is, half the value in the base case.

The high benefits

Under the high benefits scenario, the information value of social science research results to decision-

2. One of these was the project leader Dr Cynthia Bantilan, who has since left the Philippines.

makers is equal to 0.0015 of the value of the industry affected by research.

2. The world market for coconut production: an economic analysis from the perspective of the Philippines (ANRE1/1991/009)

The end-of-project reviewers of this project (ACIAR 1996) concluded that the project had not had any economic impact by the time of the review, and was unlikely to make an impact in the foreseeable future. This assessment was made despite an earlier ex-ante evaluation of the project which indicated that the project, properly implemented, could lead to benefits estimated at A$6.0 million, giving an internal rate of return on research funds of about 72% (Davis 1991).

A major reason the project has not had the intended impact is that, while it was meant to provide economic advice to the Philippine Government and the coconut industry, the project team did not make any formal reporting to the national government. Neither have the results of the project been communicated to any of the industry bodies in the major coconut-producing countries (ACIAR 1996b).

3. Postharvest physiology and technology of bananas and application to some other tropical fruits in Southeast Asia (PHT/1983/055)

This project was confined to bananas. Research was conducted in Malaysia, Philippines, Thailand and Australia. Commercially viable handling technology for bananas was successfully developed (Lizada et. al. 1987). This technology involved better control of ethylene to delay ripening of bananas under modified atmosphere storage, and use of fungicides to control stem-end rots. Four handling trials had proven the technology feasible for the export of bananas from Malaysia and the Philippines by sea to Hong Kong and Japan. In ACIAR (1986), the external reviewers of the project said that the project developed postharvest technology for handling and transport of bananas, but noted that there was still a need for research on banana pathology problems on response to modified atmospheres and on low-cost ethylene absorbents.

This is one of the projects where it is difficult to attribute benefits between ACIAR and other collaborating agencies. The project leader in the Philippines summarises the problem as follows:

The projects (PHT/1983/055 and PHT/1983/056) generated valuable technical information which proved vital to systems development. However, the matter of assigning credit to the various projects that led to improved handling systems for bananas and mangoes is not straightforward. The benefits that were eventually gained from a series of projects implemented is the culmination of activities supported by the Philippine, Australian and Canadian governments. (Dr Connie Lizada, Postharvest Horticulture Training and Research Center, Philippines, pers. comm., January 1998)

The base case

In the base case (see Table B2), project PHT/1983/055 led to about a 20% reduction in wastage of bananas between the farmgate and the retail sector. Associated with this improvement, was an increase in postharvest costs of about A$18/t, A$8/t, and A$85/t in Malaysia, the Philippines and Australia respectively (Lubulwa and Davis 1994).

The low benefits scenario

In this scenario, project PHT/1983/055 led to about half the base case reduction in wastage of bananas between the farmgate and the retail sector.

The high benefits scenario

In the high benefits scenario, the increase in postharvest costs required to achieve the reduction in wastage is lower, being about a third of those in the base case.

4. Physiological, chemical and storage characteristics of mangoes and some other tropical fruits in Southeast Asia (PHT/1983/056)

Research under this project was conducted between 1983 and 1987 with the aim of investigating postharvest characteristics of mangoes, longan, lychee and mangosteen in Australia and the Southeast Asian region. The project demonstrated that, during controlled atmosphere storage, a dual treatment of hot water followed by prochloraz was required to control stem-end rot, anthracnose and alternaria rot. The project in addition verified the

efficacy of hot benomyl and prochloraz sprays for the control of anthracnose with negligible impact on fruit quality, and demonstrated that hot benomyl controlled some types of stem-end rot. Postharvest research into other tropical fruits in Thailand under project PHT/1983/056 produced results indicating that sulfur dioxide fumigation increased the storage life of lychees to at least 90 days. For mangosteen, storage at 50°C in 5% carbon dioxide and 5% oxygen gave a safe storage interval of one month.

ACIAR (1986) concluded that:

> Low level cooling (10–15°C depending on variety) with modified atmosphere storage shows signs of giving significantly increased storage life of 6–7 weeks (for mangoes and other tropical fruits), which can be followed by normal ripening at 20–22°C to exploit regional markets. Some semi-commercial trial shipments are planned. There is a reasonable chance of a commercially useful methods becoming available as a result of these trials.

The base case

In the base case (see Table B2), project PHT/1983/056 led to about a 20% reduction in wastage of bananas between the farmgate and the retail sector. Associated with this improvement, was an increase in postharvest costs of about A$11/t in Malaysia, the Philippines, Thailand and Australia (Lubulwa and Davis 1994).

The low benefits and high benefits scenarios are constructed in the same way as the ones for PHT/1983/055 were.

5. Development of heat systems for quarantine disinfestation in tropical fruit (PHT/1990/051)

Fruit flies are a major quarantine impediment to export trade in fresh tropical fruit from Australia, Thailand, Philippines, and other Southeast Asian countries. It was proposed through project PHT/1990/051 to develop a heat system for quarantine disinfestation of fruit flies in mangoes and papaya.

This heat system worked for mangoes in Australia. It was tested on papaya and was found appropriate to papaya fruit in Philippines and Thailand. For mangoes (in Australia), and 'Solo' papaya (in Philippines and Thailand), the heat system developed under project PHT/1990/051 led to the following benefits:

- It maintained the eating quality of fruit.
- It led to increased control of disease by controlling the pathogens causing stem-end rot and anthracnose, and so led to reduced wastage of fruit.
- It did not lead to significant increases in fruit injury.
- It disinfested mangoes and papaya to a level satisfactory to get quarantine clearance for entry into markets that were inaccessible before research (e.g. Japan, New Zealand and the USA).
- Associated with the new heat system are added costs for pre-conditioning the fruit, treating the fruit with heat and for hydro-cooling the fruit after the heat treatment.

The estimates in Table 2 draw on three main sources of information:

1. A review of the project in 1993 (ACIAR 1993), which recommended an extension of the project for 1 year to allow the completion of several activities;
2. Mr Rodney Jordan (pers. comm., December 1997), project scientist who indicated that the commodity base for the benefits from the project was: mangoes (Australia and to some extent Thailand), and papaya (Philippines only).
3. Mr Terry Campbell (pers. comm., December 1997), who provided some estimates of the importance of heat systems for quarantine disinfestation in Australia.

The base case

Hardman and Rutherford (1990) estimated the 'before research' costs of vapour heat treatments for mangoes. In the base case scenario in Table 2, the 'after research' costs are estimated to be 2% lower than the 'before research'.

In the base case, the technology is applicable to only 5% of mangoes. For example, in Australia, 85% of mangoes are for the domestic market which does not require heat treatments, and 10% of the mangoes are exported to markets which do not require heat treatment for quarantine approval.

This technology is relevant only for that proportion of mangoes exported fresh. Data on fresh exports of mangoes were estimated from Johnson (1995) who gives an upper limit of 1% on the percentage of

mangoes traded fresh, and Nanjaundaswamy (1997) who estimates fresh exports of mangoes to be about 0.55% of production in India (the largest producer of mangoes).

The high and low benefits scenarios

In the 'low benefits' scenario, the 'after research' costs are 1% lower than before research. In the high benefits scenario, the technology is applicable to 15% of mangoes and papaya in the relevant countries.

6. Utilisation of fibrous agricultural residues as ruminant feeds (AS1/1983/073)

The aim of this project was to improve efficiency in the utilisation of fibrous crop residues as feed for ruminant animals, with particular attention to rice straws and stubbles. Interviews with Dr Roxas (UPLB, pers. comm., July 1997), the project leader in the Philippines, indicated that the project has not led to an impact at the farm level there. Despite the project identifying cultivars of rice which have more digestible straw with no yield penalty, rice breeding strategies have not yet incorporated rice straw digestibility as an attribute for selection. The other technologies explored in the project (for example, urea treatment of rice straw to increase digestibility) have not been adopted in the Philippines because they are more expensive than the traditional practice of feeding ruminants on untreated rice straws. The technology was not applicable to Australia. The total economic benefits given in Table 3 accrued to Thailand.

Base case

There has been some adoption of selected technologies from this project in Thailand (Professor Charan Chantalakhana, Animal Sciences, Kasetsart University, Bangkok, pers. comm., December 1997). The adoption of the practice of urea treatment of rice straw plus supplementation with concentrates (see Egan et al. 1989 for details) has been adopted by about 2% per annum of dairy farmers in Thailand. The increase in feed costs is outweighed by the benefits arising from an increase in milk yields due to feeding dairy cattle on more digestible roughage. Professor Charan Chantalakhana (Animal Sciences, Kasetsart University, Bangkok, pers. comm., December 1997) indicated that only a fraction of the maximum 25% increase in yields is due to roughage digestibility. In the base case (see Table B3) only 30% of the 25% yield increase is attributed to ACIAR project AS1/1983/073.

Low and high benefits scenarios

In the low benefits scenario, the ceiling adoption rate is 1%, while in the high benefits scenario the ceiling adoption rate is 3%.

7. Evaluation of different buffalo genotypes for draught, meat and milk production (AS2/1985/015)

The benefits estimated from research under AS2/1985/015 are based on three main sources: 1. the end-of-project review report ACIAR (1989), 2. the end-of-project collection of papers by Tulloh (1991) and 3. interviews with project scientists.

ACIAR (1989) concluded that the project generated useful results. A paper by Frisch and Vercoe (1991) summarises the results from the project for the three main commodities the project was designed to influence:

Buffalo meat

The project affected the supply of buffalo meat favourably, because it showed that F1 (swamp × river) buffalos had improved growth and reproductive rates with marginal increases in feed intake.

Buffalo milk

F1 (swamp × river) buffalos had higher milk yields than the pure swamp types.

Draught capacity

F1 (swamp × river) buffalos had draught ability at least equivalent to that of the straight-bred swamp types.

This evaluation takes into account the positive impacts on buffalo meat production and milk production. At this stage, benefits accrue to only the Philippines and Thailand where adoption of the technology from AS2/1985/015 has been observed. While Australia, Indonesia, Malaysia and Sri Lanka were also involved in the project, it is not clear whether the results have been adopted at farm level. Indonesia is only now considering setting up the infrastructure which would enable the exploitation of the results from the project. Malaysia's agricultural sector is undergoing rapid technological

change making it less reliant on animal draught power. Sri Lanka was shown to be a potential source of germplasm, and not a potential beneficiary from the project.

Project leaders in the Philippines are of the view that it would be inaccurate to attribute all the benefits from research relating to F1 (swamp × river) buffalos to ACIAR project AS2/1985/015 because the research in the Philippines was at an advanced stage when the ACIAR project started.

The base case

In the base case, the ceiling adoption of this technology is about 60%. This is based on information from Maneewan Kamonpatana (1997, pers. comm., June 1997) and Pakapun Bunyaveychewin (Research Specialist, Kasetsart University, pers. comm., May 1997). Only 10% of the benefits are attributed to ACIAR-supported research. This is more than what would accrue to the project on the basis of research budget shares. As an indication of relative contributions to the total research budget, the other buffalo-related research in the Philippines was funded by the United Nations Development Programme (UNDP) to a total budget of US$1.9m. The ACIAR budget of less than A$0.6m was spread between six countries (Australia, Philippines, Thailand, Indonesia, Malaysia and Sri Lanka).

The low and high benefits scenarios

In the low benefits scenario, the ACIAR-supported research contributes only 5% to the success of research which led to F1 (swamp × river) buffalos, and the ceiling adoption is half that in the base case.

In the high benefits scenario, ACIAR-supported research contributed 20% to the success of the research that led to F1 (swamp × river) buffalos, and the ceiling adoption is 70%.

8–9. The management of soil erosion for sustained crop production (SWL/1985/051 and LWR1/1992/001)

This section covers two closely related projects. Researchers in SWL/1985/051 studied soil erosion and the sustainability of recommended cropping practices on steeply sloping land in Philippines, Malaysia, Thailand and Australia. It was the first project of its type in some of the Asian countries.

ACIAR reviewed the project in February 1991 (ACIAR 1991) and concluded that:

> Some significant achievements of the project include the development of field instrumentation and the transfer of this advanced technology to the Asian partners, a substantial upgrade of the knowledge base and an improved understanding of the hydrologic and erosion processes by all the collaborators, and the development of a cooperative network. While much progress on the analysis side of the project has occurred, much remains to be done. This includes the estimation of soil erodibility parameters using the GUEST modelling framework, the acquisition of improved socio-economic data for determining the sustainability of recommended practices, and the introduction of a range of modelling approaches that can meet both the research and extension demands of the project.

ACIAR (1991) recommended a follow-on three year project – LWR1/1992/001. ACIAR (1995a) reviewed project LWR1/1992/001 and listed the following achievements of the project:

- the development of novel, robust and practical field and laboratory measurement techniques for erosion research at the scale of the field plot. The method used in these projects are being adopted around the developing world and is described in the ACIAR Technical and Methodology Manual for Erosion research (see Coughlan and Rose1997a);
- the project developed and extended erosion theory to tropical steeplands. The theoretical achievements and the testing of the theory against field observation was absolutely first class, and an advance on anything under way in Australia or elsewhere in the world. The reviewers commended ACIAR for supporting the level of strategic, theoretical work that was undertaken in the two projects.
- the practical application and impact on the farming community is yet to develop in Asia, but in Australia the impact on the pineapple industry has been remarkable. Letters from industry representatives which were tabled at the review gave very strong praise to the work by the Australian scientists.

The estimates in Table 2 cover impacts in Australia only. Estimation of impacts in other countries has to wait until the projects and the technologies likely to arise from them are adopted in ACIAR's partner countries in Asia.

Base case

Estimates of the cost saving in the base case are based on the following data:

Costs before	Saving /ha	Saving /ha	Yield/ha per 21 months	Saving per ton per year
A$1600/ha	60%	A$960	106 tons/ha	A$5.17

The estimate of the cultivation costs before and the savings per hectare are from Griggs (1995). The estimate of pineapple yield per hectare is from Coughlan and Rose (1997b). The technology from SWL/1985/051 and LWR1/1992/001 is applicable in all pineapple growing areas of Australia. Ceiling adoption is about 60% (Ciesiolka, pers. comm., 1997) and is reached after 15 years. The long period required before ceiling adoption is reached is because the proposed technology requires the introduction of a new machine, still to be developed, which would make it easier to plant into pineapple mulch (Ciesiolka 1995).

Low benefits scenario

Under the low benefits scenario, the proposed technology leads to half the cost reduction estimated in Griggs (1995).

A high benefits scenario

In the high benefits scenario, the technology from SWL/1985/051 and LWR1/1992/001 is adopted by all pineapple producers in Australia and achieves the cost savings in Griggs (1995). The lag to ceiling adoption levels is as in the base case.

10–11. *Rhizobium* and biological nitrogen fixation research on food grain (PN/1985/074 and PN/1987/031A)

In this set of projects, research was undertaken on rhizobium and biological nitrogen fixation in food-grain plants (mungbeans, soybeans and peanuts)

The base case: food grain legumes

For the Philippines and Australia, the estimates in Table 2 are based on the successes of the suite of projects in developing a technology which the Australian project leader (Dr Peter Dart, 1992, pers. comm.) describes as follows:

> A package of improved seed of mungbean, soybean, and peanut, Rhizobium inoculant strain and fertiliser addition was tested in a series of multi-location experiments in upland and lowland sites throughout the Philippines in collaboration with agricultural universities over a period of several years. These experiments indicated that substantial yield increases of these legumes could be obtained by seed inoculation with selected Rhizobium strains.

Long-term trials with rice showed that mungbean, and soybean planted after rice need to be inoculated to fix nitrogen. Plantings of the food legumes over several seasons and sites (a total of 56 trials) established the need to inoculate these species with rhizobia. Inoculation led to mean yield increases of 29% for mungbean, 37% for peanut, and 124% for soybean [see ACIAR (1989), Paterno and Dart (1990) and Dart et al. (1990)].

The estimates of cost reductions for mungbean, soybean, and peanuts are based on Paris et al. (1996). A ceiling adoption of 85% and data on production, consumption, and elasticities are from Paris et al. (1996)[3]. However, unlike Paris et al. (1996), the benefits from ACIAR-supported research do not include research benefits accruing before ACIAR was formed.

Low benefits and high benefits scenario

In the low benefits scenario, a lower ceiling adoption of 50% is used and half the cost reduction in the base case. In the high benefits scenario, the ceiling adoption is 100%, but with the same cost savings as in the base case.

12–15. Tree production technologies for Philippines and Australia (PN/1985/073 – tree legumes, PN/1987/031B – tree legumes, FST/1992/008, and FST/1996/110)

Project FST/1996/110 was designed to:

- conclude research to improve the establishment and productivity of tree plantations in the tropics of the Philippines and Australia, and
- enhance the national research and technical capacity to ensure uptake and application of the research outputs.

The project is the finalisation of research themes developed under three main projects: PN/1985/073

3. Data from more recent visits to selected farms suggest that this is an over-estimate of adoption. It seems that ceiling adoption is much lower. This down ward revision of adoption levels will lead to lower estimates of benefits from this suite of projects, at least in the Philippines.

(tree legumes), PN/1987/031B (tree legumes) and FST/1992/008. It aims to conclude ACIAR's direct involvement in such a way that the Filipino agencies can implement the research findings and continue some areas of research unaided where appropriate.

The data required to estimate monetary benefits from this suite of projects include:

- the areas of *Acacia mangium* and *Acacia auriculiformis* planted in Australia and the Philippines using the technology from PN/1985/073 – tree legumes, and PN/1987/031B – tree legumes;
- the cost of growing a hectare of *Acacia mangium* and *Acacia auriculiformis* in Australia and the Philippines without inoculation; and
- the cost of growing a hectare of *Acacia mangium* and *Acacia auriculiformis* with inoculation.

The base case

Philippines. Some evidence of impact of this suite of projects is provided in Arnold et al. (1997). In 1993, as part of FST/1992/008, Bukidnon Forests Incorporated (BFI)[4], set up a species evaluation trial in the Malaybalay section of its land. Of the 15 species represented in the species evaluation trial, *A. mangium* and *A. auriculiformis* (the target species of PN/1985/073 – tree legumes, and PN/1987/031B – tree legumes, FST/1992/008 and FST/1996/110) had the greatest diameter growth in 30 months among the acacias. A valuable outcome of BFI's acacia trials is the practical demonstration in the Philippines of the potential of exotic acacias such as *A. mangium* for establishment of highly productive timber plantations on lands previously considered impractical for plantation use.

BFI,as part of its policy of planting a range of fast growing species, plants up to 400 ha of *A. mangium* per year (Arnold et al. 1997). Turnbull et al. (1997) estimates that *Acacia aulacocarpa*, *A. auriculiformis*, and *A. mangium* comprise approximately 50% of the annual 1500 ha plantation establishment program of BFI. BFI are collaborators in ACIAR's projects FST/1992/008 and FST/1996/110.

While *A. auriculiformis* and *A. mangium* are prone to typhoon damage, Bukidnon – a Province of Mindanao, lies outside the typhoon belt, has an evenly distributed rainfall, and contains large areas of once forested, but now barren grasslands potentially available for reforestation (Arnold et al. 1997).

Australia. The benefits to Australia from project PN/1985/073 – tree legumes, PN/1987/031B – tree legumes, FST/1992/008, and FST/1996/110, include the following (Dr Peter Dart, University of Queensland, pers. comm., December 1997):

- Information on the specificity of the soil rhizobia populations in different locations and in acidic to alkaline soils. This benefits Australia by serving as a model for what could happen when the legumes are planted in Australia in similar soils.
- A set of rhizobium strains which may be of use for inoculants in Australia, along with methods to inoculate plants on a large scale in an industrial plantation nursery.
- Experience indicating that direct seeding of Australia acacias was not a viable option for establishment of stands for forestry
- Evidence that Australian acacias respond to inoculation even though the soil contains large populations of rhizobia capable of nodulating the acacias.
- Evidence that *Acacia mangium* and *Acacia auriculiformis* grow poorly in alkaline soils

Project PN/1987/031B (tree legumes) established the need to inoculate in the nursery, and isolated strains that are effective in nodulating *Acacia mangium* and *Acacia auriculiformis* (Dr Peter Dart, University of Queensland, pers. comm., December 1997). A collection of over 330 strains was established. These strains are now being used for nursery inoculation in Australia by the Queensland Forest Research Institute in its trials to establish native species plantations.[5] The performance of provenances tested in different locations in the Philippines is also of value in selecting suitable materials for planting in Australia because these species have not been grown previously in Australia.

4. BFI was set up in 1988 with the support of the government of New Zealand and the Philippines Department of Environment and Natural Resources. BFI covers 39,000 ha of government managed land in the province of Bukidnon.

The species targeted by this suite of projects in Australia have limitations. For example, Nickles et al. (1997) note that:

> *Acacia mangium* is not likely to become an important species in north Queensland, because it is susceptible to insect attack – especially the indigenous shoot and twig borer, and to cyclone attack (wind-throw and stem damage)'

and

> The demand for seed for *A. auriculiformis* has been only modest.

Until different data are obtained about the areas planted to the two target species in Australia using technology from projects PN/1985/073 – tree legumes, PN/1987/031B – tree legumes, FST/92/08, and FST/1996/110, it seems that annually zero[6] hectares are planted to the species in Australia.

Project FST/1996/110, the last in this suite of projects, has just started. Estimates of the impact on the cost of production are difficult at this stage. Neither PN/1985/073, nor PN/1987/031B nor FST/1992/008 managed to establish effective field trials of microsymbiotics (see ACIAR 1987, 1989b, 1995), and there is some doubt that FST/1996/110 will succeed where attempts in the past 11 years have failed (Dr Chris Harwood, CSIRO Forestry and Forest Products, pers. comm., 1996).

Estimates of the potential cost savings achievable from the project are based on claims about MYCOGROE, a bio-inoculant for the rapid establishment of pine, eucalyptus, and Agoho species (BIOTECH, undated). Plants inoculated with MYCOGROE are claimed to have 25–50% increased growth and wood yield. In addition, the product is claimed to lead to a 20% reduction in plantation establishment costs, even after allowing for the added cost of the inoculant, and a 30% reduction in the maintenance costs per hectare. In these preliminary estimates, about 50% of the claims about MYCOGROE are likely to be achieved in Philippines from this set of projects.

In this paper, the technology from projects PN/1985/073 – tree legumes, PN/1987/031B – tree legumes, FST/1992/008, and FST/1996/110 is likely to affect a small proportion of the industry, probably less than 1% of total output in the Philippines (ACIAR 1995a).

This project affects multiple products realised from the forestry industry. However, instead of allocating costs across the joint products, we follow McKenney et al. (1993) and calculate the unit cost of production based on total wood yield before and after research.

Low benefits and high benefits scenarios

In the low benefits scenario, the technology is likely to lead to half of the cost reduction achievable in the base case, with a ceiling adoption level half that in the base case. In the high benefits scenario, the technology delivers to producers twice the cost saving per ton.

16–18. New approaches to the control of bacterial wilt (*Pseudomonas solanacearum*) in tomato and potato (CS1/1990/015, CS1/1994/052 and CS1/1996/231)

Estimates of benefits from this project are based on the following achievements from research.

Project CS1/1990/015 developed DNA fingerprinting techniques which could specifically identify small numbers of *Pseudomonas solanacearum* in plant tissue. The same techniques could differentiate different biovars of this organism and further differentiate different isolates belonging to the same biovar group

Project CS1/1994/052 seeks:

- to refine the techniques of molecular biology so they can be used to identify *P. solanacearum* in the laboratory and field conditions in Asia; and
- to train staff through collaboration in these techniques.

5. However, from the experience of raising seed orchards of acacia species over the last seven years, it is not clear whether the inoculants from PN/1985/073-tree legumes, PN/1987/031B-tree legumes, FST/1992/008, and FST/1996/110 are necessary (Dr D.G. Nickles, Queensland Forest Research Institute, Indooroopilly, Queensland, pers. comm., January 1998).

6. This is confirmed by Dr D.G. Nikles (Queensland Forest Research Institute, Indooroopilly, pers. comm., January 1998) who stated that the seedling seed orchards his group has developed over the last few years has been to service the overseas demand for planting materials for *Acacia mangium* and *Acacia auriculiformis*. No commercial planting of *Acacia mangium* and *Acacia auriculiformis* has occurred to date in Australia.

Integrated disease management (IDM) is a possible solution to bacterial wilt. Controls include the provision of uninfected seed, especially of potatoes, breeding resistant cultivars, systems of crop rotation, and soil amendment. Project CS1/1994/052 will contribute to the breeding of resistant cultivars. In addition, the use of weakened strains of *Pseudomonas solanacearum* to control the bacterium in potatoes and tomatoes will also be studied.

CS1/1996/231 makes available the breeding and other experience of the Asian Vegetable Research and Development Center (AVRDC) to ACIAR project CS1/1994/052. AVRDC is the major breeding institute for bacterial wilt research in Asia on many affected crops. CS1/1996/231 will conduct epidemiological experiments to correlate ecotypes, genotypes and genome variation in *P. solanacearum*. The approaches to be used will characterise the genomes of the major ecotypes of *P. solanacearum* contributing to bacterial wilt of tomato in the Philippines, Taiwan, Indonesia and Australia. Analysis of data to be obtained is expected to show DNA probes are able to provide a technically simplified classification system which is of greater use than those currently available.

The base case

The estimation of benefits recognises that it will take a long time before the technology from these projects leads to farm-level impacts. Most of the activities are concentrated on high-level laboratory science, and there seem to be many areas of uncertainty in the technology to be developed. For example, a series of potentially resistant tomato cultivars developed at AVRDC over many years, while resistant when grown at AVRDC show susceptibility when grown in the Philippines and Indonesia. The ceiling adoption of the technology is assumed to be about 30%. It is possible that many farmers will not adopt the resistant cultivars because the planting materials may cost more than those currently used. Furthermore, farmers can avoid the extreme impacts of the bacterial wilt by adopting appropriate crop-rotation practices.

The high and low benefits scenarios

In the high benefits scenario, bacterial wilt leads to a yield penalty (before research) which is 5% more than in the base case, and the ceiling adoption is double that in the base case. In the low benefits scenario, the bacterial wilt leads to a yield penalty (before research) which is 5% less than in the base case, and the ceiling adoption is half that in the base case.

19. Control of papaya ringspot virus in the Philippines by development of PRSV resistant hybrids (CS1/1991/007)

Papaya ringspot virus (PRSV) is the most serious disease of papaya world-wide, and losses to the papaya industry in the Philippines in recent years have been devastating. One strategy to control the disease is to breed resistant hybrids using lines known for their tolerance. Researchers in this project aim to introduce known resistance to the disease into commercial papaya (*Carica papaya*) from other *Carica* species, using in-vitro embryo culture to surmount problems of incompatibility between species.

The project was reviewed by ACIAR (1996a) and extended. This ex-ante assessment focuses entirely on the benefits to the Philippines. Although PRSV has occurred in Australia, eradication has proved successful and there is no evidence that the virus is present in commercial papaya plantations (Dr John Thomas, QDPI, pers. comm., 1998).

At present, the Southern Tagalog region in the Philippines has suffered the greatest impact of the disease, and estimated benefits from the research are applicable to this region only. However, the virus is spreading to other regions, so the impacts may be on the conservative side.

Base case

A preliminary evaluation was undertaken by Bantilan (1992). The results of before and after cost analyses show that the development of a variety which is resistant to PRSV has the potential to reduce the unit cost of papaya production by approximately 50% with an increase of 350% in the yield. The cost analysis information was combined with research lags of 9 years and a maximum adoption rate of 100%, to estimate the expected benefits to the Southern Tagalog region of the Philippines.

Low benefits and high benefits scenarios

In the low benefits scenario, the technology is likely to lead to half the cost reduction achievable in the base case. In the high benefits scenario, the technology could lead to a cost saving 25% higher than those in the base case.

20–21. Biological control of *Chromolaena odorata* in Indonesia, Papua New Guinea and the Philippines (CS2/1991/010, CS2/1996/091)

Chromolaena odorata (Siam weed) originates in the tropical Americas, but it has become one of the worst weeds in the wet tropics of Asia and Africa. It is also regarded as the most serious weed threat to Australia. These ACIAR projects concentrate on pastoral areas in Indonesia (especially Timor) affected by the weed, and in providing control agents to agencies in the Philippines and Papua New Guinea.

The first phase of this project, which concentrated on Indonesia and the Philippines, resulted in the introduction and establishment of an arctiid moth into Indonesia and this has resulted in good control of Siam weed in several areas of Sumatra. Project CS2/1991/010 also resulted in the introduction of another natural enemy, the gall-forming tephritid fly (*P. connexa*), into Indonesia. This insect has established in the field in Sumatra, Java and Timor.

The second phase of the project seeks to mass rear and release existing biological control agents in all areas of Indonesia, Philippines and Papua New Guinea, with the ultimate objective of establishing them in all areas of both countries. Successful biological control of Siam weed in Indonesia where the weed is widespread, will remove the need for costly manual control of the weed, reduce plantation and forestry establishment costs and increase livestock production.

Base case

Indonesia. This ex-ante evaluation estimates the economic benefits to Indonesia through increased cattle production and reduced establishment costs for rubber and palm oil. Given that control has been achieved through the first phase of the project, adoption is assumed to start in year 4 and reach a maximum adoption level of 70%. Adoption in this project relates to the establishment of biological control agents and control of the weed.

Papua New Guinea. In PNG, where the weed is still not widespread (and therefore incurring minimal economic losses), the economic benefits will come from weeding costs which would otherwise have been incurred as the weed spread throughout the country.

Australia. In Australia, the benefits will come from reductions in the number of new infestations found in the country. There has been one major infestation in Australia which is currently being eradicated using chemicals.

Philippines. In the Philippines, no progress was made in this project due to failure to secure a permit to import *P. connexa*. (ACIAR 1995b).

Low benefits and high benefits scenarios

The low benefits scenario assumes that the technology will lead to 50% adoption while the high benefits scenario assumes that the technology will lead to 100% adoption.

Table 2. Estimated benefits (A$m) from selected projects based at the University of Philippines, Los Baños, 1985–1995[a]

No. of studies	Project no.	Title	Research costs (A$m, 1994)	Basis for evaluation)	Total economic benefits (A$m, 1994)			Internal rate of return (%)			Publication, training and other impacts	Environmental impacts
					LOW	BASE CASE	HIGH	LOW IRR	BASE CASE	HIGH IRR		
1	EFS/1986/024	Research priorities for Philippines agriculture	0.2319	The project review report by ACIAR (1990)	0.96	1.91	2.87	19	26	31	A number of training workshops was held on research evaluation and research Prioritisation. Two post-graduate trainees (1 MSc and 1 PhD)	Zero
2	ANRE1/1991/009	The world market for coconut production: an economic analysis from the perspective of the Philippines	0.563	A negative technical review of the project ACIAR (1996b)	Zero	0	Zero	Negative	Negative	Negative	There were several positive training impacts from the project (including exposure of the project team to general equilibrium modelling).	Zero
3	PHT/1983/055	Postharvest physiology and technology of bananas	0.801	ACIAR (1986), external review of the project.	24.2	51.4*	55.6	39	48*	49	At least 5 research papers were produced	Nil
4	PHT/1983/056	Physiological, chemical and storage characteristics of mangoes and some other tropical fruits	1.001	ACIAR (1986), external review of the project	17.8	37.6*	40.4	33	41*	42		Nil
5	PHT/1990/051	Development of heat systems for quarantine disinfestation in tropical fruit	0.852	ACIAR (1993), external review of the project	0.56	1.16	4.6	5	11	29	The project has produced 47 papers and reports.	PHT/1990/051 solutions facilitate the replacement of methyl bromide.
6	AS1/1983/073	Utilisation of fibrous agricultural residues as ruminant feeds	0.8939	Project termination report by Egan et al. (1989)	0.25	0.99	2.24	0.9	8.7	13.9	Six researchers attended a short course. 48 research papers and 4 theses produced.	
7	AS2/1985/015	Evaluation of different buffalo genotypes for draught, meat and milk production	0.5892	End-of-project review report ACIAR (1989), (b) Tulloh (1991) (c) interviews with project scientists.	0.154	1.21	3.28	1.6	12.5	21.4	Two researchers attended a workshop. At least 5 research papers produced.	

[a] Italicised project numbers indicate projects in progress at the time of this study

* The benefits that were eventually gained from a series of projects implemented is the culmination of activities supported by the Philippine, Australian and Canadian governments (Dr Conception Lizada, Postharvest Horticulture Training and Research Center, Philippines, pers. comm., January 1998). The share of the research benefits is small, probably about 10%.

Table 2. (cont'd) Estimated benefits (A$m) from selected projects based at the University of Philippines, Los Baños, 1985–1995[a]

No. of studies	Project no.	Title	Research costs (A$m, 1994)	Basis for evaluation)	Total economic benefits (A$m, 1994)			Internal rate of return (%)			Publication, training and other impacts	Environmental impacts
					LOW	BASE CASE	HIGH	LOW IRR	BASE CASE	HIGH IRR		
8–9	SWL/1985/051 and LWR1/1992/001	The management of soil erosion for sustained crop production	2.0142	(a) ACIAR (1991), ACIAR (1995a), the end-of-project review of SWL/1985/051 and LWR1/1992/001 respectively (b) Interviews with project scientists Only Australian benefits are included.	0.47	0.94	2.55	Negative	3	9.7	Training was a major component. In the Philippines, the project led to 2 PhDs, 4 MSc graduates and 2 BSc graduates. The project sites are still used for training and extension purposes at UPLB, Los Baños.	In the long run these projects will have major environmental impacts in Asia In Australia, the project increased sustainability of pineapple production by reducing off-site pollution by growers.
10–11	PN/1985/074 (Soybean & mungbean) PN/1987/031A (grain legumes	Rhizobium and biological nitrogen fixation research on food grain legumes	0.3868 (Research costs of PN/1987/031A = half of research costs of PN/1987/031)	(a) ACIAR (1987) end-of-project review of PN/1985/074 (b) ACIAR (1989b), mid-term review of PN/1987/031A.	1.9	5.23	7.27	14.5	21.7	24	Three PhD, and 5 researchers attended 1 short course each; at least 28 journal articles were published and 5 conference papers produced.	The adoption of technologies developed in these projects reduces the need to use chemical nitrogen fertilisers.
12–15	PN/1985/073 (tree legumes), PN/1987/031B (tree legumes) *FST/1992/008* and *FST/1996/110*	Tree establishment technologies in the Philippines	1.1072 (Research costs of PN/1987/031B = half of research costs of PN/1987/031)	(a) ACIAR (1987) (b) ACIAR (1989b), mid-term review of PN/1987/031B. (c) ACIAR (1995c)	0.34	0.67	1.35	Negative	4.5	9.4	In addition to on-the-job training, 1 PhD, and 14 researchers attended short courses; a number of journal articles were published.	In the long run the projects are likely to lead to significant environmental impacts, arising from more successful reforestation.
16–18	*CS1/1990/015, CS1/1994/052* and *CS1/1996/231*	New approaches to the control of bacterial wilt (*Pseudomonas solanacearum*) in tomato and other vegetable and crop plants.	0.8912	ACIAR (1994) end-of-project review of CS1/1990/015	2.59	2.71	2.81	13.3	13.5	13.7	The project started the Crawford Fund Master classes in biotechnology, there were 9 visiting science Fellows and at least 9 publications.	Nil

Table 2. (cont'd) Estimated benefits (A$m) from selected projects based at the University of Philippines, Los Baños, 1985–1995[a]

No. of studies	Project no.	Title	Research costs (A$m, 1994)	Basis for evaluation)	Total economic benefits (A$m, 1994)			Internal rate of return (%)			Publication, training and other impacts	Environmental impacts
					LOW	BASE CASE	HIGH	LOW IRR	BASE CASE	HIGH IRR		
19	*CS1/1991/007*	Control of papaya ringspot virus in the Philippines by development of PRSV resistant hybrids	1.08	ACIAR (1996a), end-of-project review of phase 1 of CS1/1991/007. Communication with project leader.	1.71	3.46	4.35	11.2	16.7	18.6	Major training impacts including 1 PhD, 1 short course and 1 long course. 19 papers were produced.	None
20–21	*CS2/1991/010* and *CS2/1996/091*	Biological control of *Chromolaena odorata* in Indonesia and the Philippines	1.3	ACIAR (1995b)	12.9	24.9	50.1	36.1	46.5	60.1	Six personnel form Indonesia and 3 from the Philippines attended a training course on biological control. There have been significant training impacts. 3 scientists have attended training workshops, 6 papers have been produced	There is potential for major environmental impacts if an appropriate biological control is established in the collaborating countries.

Table 3. Distribution of estimated benefits by country in the base case scenario for 21 ACIAR-supported projects based at UPLB, Philippines (A$m, 1994)[a].

No. of projects	Project no.	Title	Total economic benefits (A$m, 1994)	Australia	Philippines	Other Countries	Other countries in the analysis
1	EFS/1986/024	Research priorities for Philippines agriculture	1.91	0	1.91	0	None
2	ANRE1/1991/009	The world market for coconut production: an economic analysis from the perspective of the Philippines	0	0	0	0	None
3	PHT/1983/055	Postharvest physiology and technology of bananas	51.4	6.7	40.7a	4.0	Malaysia
4	PHT/1983/056	Physiological, chemical and storage characteristics of mangoes and some other tropical fruits	37.6	3.6	15.9a	2.7 15.4	Malaysia Thailand
5	PHT/1990/051	Development of heat systems for quarantine disinfestation in tropical fruit	1.16	0.07	0.01	1.72 –0.63[b]	Thailand Rest of world
6	AS1/1983/073	Utilisation of fibrous agricultural residues as ruminant feeds	0.99	0	0	0.99	Thailand
7	AS2/1985/015	Evaluation of different buffalo genotypes for draught, meat and milk production	1.21	0	0.52	0.68	Thailand
8 – 9	SWL/1985/051 and LWR1/1992/001	The management of soil erosion for sustained crop production	0.94	0.94	0	0	None
10 – 11	PN/1985/074 (soybean & mungbean) PN/1987/031A (grain legumes	Rhizobium and biological nitrogen fixation research on food grain legumes	5.29	4.46	0.83	0	None
12 – 15	PN/1985/073 (tree legumes), PN/1987/031B (tree legumes) FST/1992/008 and FST/1996/110	Tree establishment technologies in the Philippines	0.67	0	0.67	0	None
16 –18	CS1/1990/015, CS1/1994/052 and CS1/1996/231	New approaches to the control of bacterial wilt (Pseudomonas solanacearum) in tomato and other vegetable and crop plants.	2.71	0.295	0.163	0.79 m 1.46 m	Indonesia Taiwan
19	CS1/1991/007	Control of papaya ringspot virus in the Philippines by development of PRSV resistant hybrids	3.46	0	3.46	0	Thailand Malaysia
20–21	CS2/1991/010 and CS2/1996/091	Biological control of Chromolaena odorata in Indonesia and the Philippines	24.91	0	0	24.78 0.01 0.12	Indonesia PNG Rest of the world
Total	Not applicable	Not applicable					

[a] The benefits that were eventually gained from a series of projects implemented is the culmination of activities supported by the Philippine, Australian and Canadian governments (Dr Conception Lizada, Postharvest Horticulture Training and Research Center, Philippines, pers. comm., January 1998). The share of the research benefits is small, probably about 10%.

[b] An open economy model is applied here and there is a small net loss to the rest of the world.

Conclusions

This paper has summarised preliminary estimates of benefits from twenty-one ACIAR-supported agricultural research projects. These estimates suggest that, for an expenditure of about A$12m, ACIAR-supported research could be associated with a total benefits of A$132m. This equates to a benefit–cost ratio of over 11, which is considered to be high. However, the estimates are confounded by the following issues:

Attribution of benefits

The estimates in this paper take into account funds jointly invested by Australian and overseas institutions collaborating in an ACIAR project. But they do not take into account expenditures incurred by other agencies before or after an ACIAR project. In many cases, the amounts of these expenses are not readily available. Using ACIAR's share in the total budget for activity is likely to underestimate the contribution of ACIAR to the technologies in question.

If the contribution of the ACIAR activity to the total benefits is 10% then, for an expenditure of about A$12 m, ACIAR-supported research could be associated with a total benefits of A$13.2 m. This equates to a benefit cost ratio of about 1.1. If the contribution of the ACIAR activity is less than 10%, then the twenty-one research projects evaluated in this paper will generate a net loss. If the contribution of ACIAR-supported research is more than 10%, then the benefits from the twenty-one projects based at UPLB exceed the total discounted research costs of the projects.

Spillovers

On the other hand, the benefits estimated in the paper have been conservative in that they have ignored the possible spillover benefits from ACIAR-supported research. For example, if the research on bacterial wilt succeeds, it is likely to have implications for many other commodities and in many other countries than those included in the analysis. However, before technical spillovers are realised added, adaptive research (a cost) would be needed and farmers in the spillover countries would have to adopt the technology. Thus, if spillover benefits are to be included in the analysis, it needs to be done with caution.

Choice of time to assess impact

About half of the evaluations deal with projects which are still in progress. This means that, in many cases, the project teams have had to predict adoption patterns.

Assessing benefits from research soon after its completion means that the evaluation has to predict adoption patterns. However, the earlier a project is assessed, the better the estimates of its technical impacts. Delaying the estimation of impacts improves the data on adoption. However, the longer the delay, the fuzzier is the definition of the technology from an ACIAR project. This is because, over time, farmers modify the technology delivered. As ownership of farms or firms change, new owners may not remember the origins of the various technologies (ACIAR or non-ACIAR). The choice of the time to evaluate a project then involves balancing these aspects.

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Appendix A

Description of twenty-one ACIAR-supported research projects based at UPLB (1983–1995)

1. Research priorities for Philippines agriculture (Project EFS/1986/024)

This is one of four projects which were adjuncts to the ACIAR central coordinating project on research priority assessment and coordination. This project applied at individual country level, in the Philippines, the general global priorities assessment model based on the concept of economic surplus. The model was adapted and modified to suit local needs in the Philippines. The analyses undertaken provided a basis for more coordinated agricultural research effort, with increased ability to predict the outcome of research initiatives and to better understand commodity price trends in relation to supply and demand.

2. The world market for coconut production: an economic analysis from the perspective of the Philippines (Project ANRE1/ 1991/009)

The Philippines' coconut industry contributes substantially to the country's economy. However, changes in world markets for oil and other coconut products have far-reaching implications for the industry. This study examined the influences affecting the international market for coconut products and undertook a quantitative assessment of the factors determining demand in the major consumer nations of the world. It also identified threats to the industry posed by international trade restrictions, competition from other oils, and mycotoxin contamination. This study was designed to help the Philippines to adjust domestic policies in line with expansion or contraction of the market and minimise any adverse effects on the industry.

3. Postharvest physiology and technology of bananas and application to some other tropical fruits in Southeast Asia (Project PHT/1983/055)

This project was confined to bananas. Research was conducted in Malaysia, Philippines, Thailand and Australia. This technology involved better control of ethylene to delay ripening of bananas under modified atmosphere storage, and use of fungicides to control stem-end rot.

4. Physiological, chemical and storage characteristics of mangoes and some other tropical fruits in Southeast Asia (Project PHT/1983/056)

Research under this project was conducted between 1983 and 1987 with the aim of investigating postharvest characteristics of mangoes, longan, lychee and mangosteen in Australia and the Southeast Asia region. The project demonstrated that, during controlled atmosphere storage, a dual treatment of hot water followed by prochloraz was required to control stem-end rot, anthracnose and alternaria rot. Also, the project verified the efficacy of hot benomyl and prochloraz sprays for the control of anthracnose with negligible impact on fruit quality, and demonstrated that hot benomyl controlled some types of stem-end rot. Postharvest research into other tropical fruits in Thailand under PHT/1983/056 produced results indicating that sulfur dioxide fumigation increased the storage life of lychees to at least 90 days. For mangosteen, holding at 50°C in 5% carbon dioxide and 5% oxygen permitted safe storage for one month.

5. Development of heat systems for quarantine disinfestation in tropical fruit (Project PHT/1990/051)

Fruit fly infestations are a serious technical barrier to international trade in staple fruits and vegetables, and the need for acceptable quarantine disinfestation measures is rated highly by countries in which fruit fly occurs. Heat treatment is a viable method for many fruits and has the additional benefit of being residue-free. This project sought to expand the use of several different heat treatments across a wide range of commodities, and establish protocols for disinfestation procedures that can be applied to many fruits and vegetables. The project has led to the opening up new export markets for Southeast Asian countries and Australia, specifically for mango and papaya.

6. Utilisation of fibrous agricultural residues as ruminant feeds (Project AS1/1983/073)

This project was aimed at improving the efficiency of fibrous agricultural residues as ruminant feeds and consisted of two interacting parts:

- fundamental studies and applied feeding studies conducted mainly in Australia; and
- applied feeding studies, conducted at Khon Kaen University, Thailand, and the University of the Philippines, using locally available straw and feed supplements.

7. Evaluation of different buffalo genotypes for draught, meat and milk production (Project AS2/1985/015)

Many developing countries rely on buffalo, but lack any comparative evaluation of the different breeds and strains. This project sought to determine the available genetic, environmental and sociological options to improve buffalo productivity. It encouraged research institutes in Southeast Asia with two or more breeds or strains to investigate differences in feed utilisation, in productive performance and in draught power, using only feeds available for local small holders. The Australian scientists aimed to establish mechanisms for coordination and transfer of the institutes' research findings and encourage their application in small holder systems in the region to improve productivity.

8. The management of soil erosion for sustained crop production (Project SWL/1985/051)

Soil conservation research is receiving new emphasis in many Southeast Asian countries, where socioeconomic pressures are causing serious land degradation and reduced productivity on steep and sloping lands. This project focused on surface management of land, and recorded information for a range of cropping practices, slopes, soil types and rainfall in Malaysia, Philippines and Thailand. The data obtained enabled researchers to compare different cropping practices, to validate soil erosion models for steep slopes with high rainfall, and to predict soil erosion in various situations.

9. Sustainable cropping systems for tropical steeplands (Project LWR1/1992/001)

Project LWR1/1992/001 stemmed from an earlier one (SWL/1985/051), and addressed the sustainability of subsistence agriculture as it moves into steeplands at sites in Malaysia, the Philippines, Thailand and Australia. Project scientists employed computer models to assess 1) soil hydrology and sediment transport to test different options for reducing soil loss, and 2) different cropping systems to compare relative sustainability of crop production. These assessments have provided 'indicators of sustainability' to assist governments with land-use planning in steeplands.

The objectives of LWR1/1992/001 were as follows:

- Predicting the run-off from different cropping and land management systems
- Determining the effect of cover, soil strength and depositibility on sediment concentration
- Comparing various process models, and empirical data
- Determining nutritional losses in sediments
- Determining the effect of land management on soil physical, chemical, and biological properties
- Undertaking cropping systems simulation modelling

- Undertaking studies on occurrence of subsurface throughflow on hillslopes
- Developing methodologies for soil erosion and hydrology research.

10. Ecology of rhizobium nodulating grain legumes (Project PN/1985/073)

This sub-project researched the need for inoculation, particularly of soybean and mungbean, in different agroclimatic zones of the Philippines. It examined whether Rhizobium numbers decreased during the soil flooding in paddy rice culture, how inoculum strains survive in different environmental conditions, and the effects of soil pH, farming systems (upland or lowland), fertilisers, previous cropping history and soybean germplasm type on plant nodulation in the field trials. It also examined whether soybeans in the Philippines were predominantly nodulated by slow-growing strains or by more promiscuous fast-growing strains with more widespread geographical distribution, and the effect of the host genome on this. This research indicated the need to inoculate soybean and mungbean in the Philippines and that breeders needed to take more account of nodulation characteristics in their programs.

11. Biological nitrogen fixation in food legume production systems in the Philippines (Project PN/1987/031A)

This project stemmed from ACIAR-funded research into biological nitrogen fixation (BNF) conducted in the early 1980s. It addressed Rhizobium inoculation of soybeans and mungbeans in the Philippines in a range of cropping systems in different regions of the country, and developed suitable inoculation procedures using selected species and nutritional manipulation to enable production of food legumes on acid upland soils.

12. Ecology of rhizobium nodulating tree legumes (Project PN/1985/073)

This sub-project had the following main aims:

- to determine the interrelations between Rhizobium strains and promising legume tree species and cultivars in different regions of the Philippines;
- to select effective and competitive Rhizobium strains suitable for use as inoculants;
- to select strain–host cultivar combinations tolerant of soils with low pH and high aluminium levels and or find other economic management practices to ameliorate this stress; and
- to determine the response to microbial inoculation of promising tree species in different field environments. The research concentrated on 11 tree species.

13. Biological nitrogen fixation in food legume production systems in the Philippines (Project PN/1987/031)

This project addressed Rhizobium relationships of tree legumes in the Philippines. Researchers assessed the need for microbial inoculations of trees, and devised procedures to incorporate promising leguminous trees into reforestation and agroforestry programs.

14. Tree establishment technologies in the Philippines (Project FST/1992/008)

The Philippines needs suitable fast-growing trees to combat severe land degradation and to boost supplies of timber and fuelwood. But the effectiveness of reforestation and agroforestry programs is hampered by a limited choice of species, poor growth in nurseries and low survival and growth rates after field planting. This project tested a range of fast-growing tree species and provenances identified in earlier ACIAR projects to select suitable lines for reforestation programs. Scientists also developed nursery management techniques, including the establishment of the microbial relationships necessary for healthy growth and field management techniques to overcome weeds and provide adequate nutrition for rapid plant growth.

15. Tree production technologies for Philippines and Australia (Project FST/1996/110)

This project was designed to conclude research on a forestry problem, i.e. to improve the establishment and productivity of tree plantations in the tropics of the Philippines and Australia, and to enhance the national research and technical capacity to ensure

uptake and application of the research outputs. The project is the finalisation of research themes developed under FST/92/08. It aims to conclude ACIAR's direct involvement in such a way that the Filipino agencies can implement the research findings and continue some areas of research unaided where appropriate. Large-scale industrial plantations based on tropical species are a possible outcome of this research, provided research presents answers to the present technical constraints and to the lack of adequate information to make large investment decisions.

The Philippines will benefit by development of local technologies for improved plantation establishment, access to superior germplasm, and enhanced scientific skills for conducting further research as required. Australia will benefit by enhancing local expertise and experience that will provide an impetus to reforestation in the tropics, and by the development of options for alternative land use in rural areas, particularly on degraded or unproductive agricultural lands.

16. New approaches to the control of bacterial wilt (*Pseudomonas solanacearum*) in tomato and other vegetable and crop plants (Project CS1/1990/015)

The organism causing bacterial wilt, *Pseudomonas solanacearum*, attacks a wide range of vegetables and crop plants. Traditional breeding programs for crop resistance and specific agronomic practices can minimise damage in some cases, but new approaches are needed to have any real impact on the disease. This project conducted research to develop molecular genetic techniques that led to the identification of different strains of *P. solanacearum*, identified the bacteria's virulence genes and determined the interaction between plant and bacterial genes in the onset of infection.

CS1/1990/015 resulted in several molecular genetic techniques, one which can distinguish *P. solanacearum* from other pathogenic and soil bacteria and others which can make fine distinctions between different 'biovars' and field types of *P. solanacearum*.

The project also trained scientists from Southeast Asia in the skills to undertake the tests through upgrade courses and master classes.

17. Control of bacterial wilt (*Pseudomonas solanacearum*) by agricultural biotechnology (Project CS1/1994/052)

This project is using techniques developed under CS1/1990/015 to develop an integrated program for bacterial wilt management in the field, focusing on two target crops, tomato and potato. Scientists will try to understand how this bacterium can cause disease in such a wide range of plants and how it naturally acquires such genetic variability. The project will provide valuable new data for integrated disease management of bacterial wilt in other tropical crops and will contribute to the breeding of resistant cultivars.

Ultimately, the successful application of the knowledge gained during this project should minimise bacterial wilt and increase the yields of susceptible crops.

18. Control of bacterial wilt (*Pseudomonas solanacearum*) by agricultural biotechnology (Project CS1/1996/231)

This project is linked with ACIAR project CS1/1994/052 and makes it possible to involve the Asian Vegetable Research and Development Center in the epidemiological experiments to correlate ecotypes, genotypes and genome variation in *Pseudomonas solanacearum*. The approaches to be used will characterise the genomes of the major ecotypes of *P. solanacearum* contributing to bacterial wilt of tomato in the Philippines, Taiwan, Indonesia and Australia. Analysis of data to be obtained is expected to show DNA probes are able to provide technically simplified classification system which is of great use than those currently available.

19. Control of papaya ringspot virus in the Philippines by development of PRSV resistant hybrids (Project CS1/1991/007)

Papaya ringspot virus (PRSV) is the most serious disease of papaya world-wide, and losses to the papaya industry in the Philippines in recent years have been devastating. One strategy to control the disease is to breed resistant hybrids using lines known for their tolerance. This project aims to introduce known resistance to the disease into

commercial papaya (*Carica papaya*) from other *Carica s*pecies, using in-vitro embryo culture to surmount problems of incompatibility between species.

20. Biological control of *Chromolaena odorata* in Indonesia and the Philippines (Project CS2/1991/010)

Chromolaena odorata (Siam weed) originates in the tropical Americas, but it has become one of the worst weeds in the wet tropics of Asia and Africa. It is also regarded as the most serious weed threat to Australia. This ACIAR project concentrates on pastoral areas in Indonesia (especially Timor), and also provides control agents to agencies in the Philippines. The project scientists provide advice and support before release of control agents and then follow up with studies after their release.

21. Biological control of *Chromolaena odorata* in Indonesia, Papua New Guinea and the Philippines (Project CS2/1996/091)

This project continues the work from CS2/1991/010. This project will continue to release and monitor a variety of insects for control of the weed in Indonesia (especially Timor) and Papua New Guinea. The scientists will provide advice and support before the release of control agents and then follow up with studies after their release.

Appendix B

Values of key variables and assumptions made in the estimation of benefits from twenty-one ACIAR-supported research projects based at UPLB (1983–1995)

Table B1 Data used in the estimation of benefits from ACIAR EFS/1986/024

C1	C2	C3	C4	C5	C6	C7
Commodity	Gross value of production (1994) A$m	Expected value of perfect information per unit value of research dollar invested	PCCARD priority before research	NAREA 2 priority after research	Value of information as a proportion of the value of the industry (s)	Net research benefit (A$m/year)
Rice	1275	68	3	1	0.001	1.27
Sugarcane	333	65	1	1	0.001	0
Corn	565	20	2	1	0.001	0.56
Chicken	575	416	5	1	0.001	0.57
Hog	1134	25	6	1	0.001	1.13
Banana	213	117	3	2	0.001	0.21
Coffee	218	120	2	2	0.001	0
Roundscad	452	Not stated	2	2	0.001	0
Coconut	601	7	1	2	0.001	0
Pineapple	137	663	3	3	0.001	0
Tobacco	58	5	4	3	0.001	0.057
Tuna	209	169	1	3	0.001	0
Milkfish	227	290	2	3	0.001	0
Garlic	27	342	1	4	0.001	0
Prawn	391	101	2	4	0.001	0
Carabao/cattle	10473	3	3	4	0.001	0
Tomato	37	48	2	4	0.001	0
Tilapia	77	42	1	5	0.001	0
Cassava	94	13	2	5	0.001	0
Sweet potato	63	6	2	5	0.001	0
Cocoa	9	10	1	6	0.001	0
Cotton	2	1	2	6	0.001	0
Soybean	2	2	2	6	0.001	0

Notes:
C2 Gives the product of the quantity produced and the farm gate price for the different commodities.
C3 This column gives the research benefits as estimated from EFS/1986/024 divided by the total annual research expenditure in the sector.
C4, C5 The number 1 indicates a commodity in the highest priority group, while a 6 indicates a commodity in the lowest priority group.
C7 In the analysis, benefits accrue with respect to commodities which were deemed low priority for research funding purposes before project EFS/1986/024, but which project EFS/1986/024 showed to be of much higher priority if Philippines aimed at maximising economic benefits.

Table B2 Data and assumptions used in estimating benefits from three UPLB-based postharvest projects (PHT/1983/055, PHT/1983/056, and PHT/1990/051)

Project	**PHT/1983/055**		**PHT/1983/056**							**PHT/1990/051**			
Country	Australia	Malaysia	Malaysia	Malaysia	Thailand	Thailand	Thailand	Thailand	Australia	Australia	Thailand	Thailand	Philippines
Commodity	Banana	Banana	Mango	Rambutan	Mango	Longan	Lychee	Mangosteen	Mango	Mango	Mango	Papaya	Papaya
Production (000 tonne)	165	135	15	37	894	87	24	90	12	27	650	550	98
Consumption (000 tonne)	165	135	15	37	894	87	24	90	12	27	650	550	98
Price/tonne	904	337	719	528	1,153	1,499	1,845	1,153	1,611	3,385	3,385	519	410
Elasticity of Supply	0.1	0.1	0.1	10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Elasticity of Demand	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.8	1.5	1.5	1.5	1.5
Year the project started	1983	1983	1983	1983	1983	1983	1983	1983	1983	1991	1991	1991	1991
First year of adoption	1994	1994	1994	1994	1994	1994	1994	1994	1994	1993	1993	1993	1997
Adoption level in first year of adoption	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ceiling adoption level (proportion)	0.2	0.2	0.5*	0.5*	0.2*	0.2*	0.2*	0.2*	0.65*	100	100	100	100
Years to ceiling adoption	1	1	12	12	12	12	12	12	12	5	5	5	5
Reduction in wastage (%)	20	20	10	20	5	10	10	10	7	89 (of exports)	89 (of exports)	89 (of exports)	89 (of exports)
Change in postharvest cost (A$)	85	18	11	50	11	129	129	0	11	7.7	7.7	7.7	7.7
Unit cost reduction (A$)	na	na	na	na	na	na	Na	na	na	na	na	na	na

* In the last 8 years of the time horizon, there is 'disadoption' of chemical-based technologies from this project as they are replaced by non-chemical methods for post harvest control of disease and shelf life extension of fruit.

Table B3 Data and assumptions used in estimating benefits from animal sciences projects (AS1/1983/073 and AS2/1985/015)

Project	**AS1/1983/073**	**AS2/1985/015**			
Country	**Thailand**	**Philippines**	**Thailand**	**Philippines**	**Thailand**
Commodity	**Milk**	**Buffalo meat**	**Buffalo meat**	**Buffalo milk**	**Buffalo milk**
Production (000 tonne)	438,000	46	63	16	6
Consumption (000 tonne)	438,000	46	63	16	6
Price/tonne	251	2,085	2085	63	63
Elasticity of Supply	0.2	1	1	1	1
Elasticity of Demand	1.08	0.2	0.2	0.2	0.2
Year the project started	1984	1985	1985	1985	1985
First year of adoption	1993	1991	1991	1991	1991
Adoption level in first year of adoption	0.05	0.05	0.05	0.05	0.05
Ceiling adoption level (proportion)	0.02	0.6	0.6	0.6	0.6
Years to ceiling adoption	5	12	12	5	5
Reduction in wastage (%)	na	na	na	na	na
Change in postharvest cost (A$)	na	na	na	na	na
Unit cost reduction (A$)	2	11	11	1	1

Table B4 Data and assumptions used in estimating benefits from rhizobium research projects based at UPLB, Los Baños (SWL/1985/051, LWR1/1992/001, PN/1985/074, PN/1987/031A, PN/1985/073, PN/1987/031B, FST/1992/008 and FST/1996/110)

Project	**SWL/1985/051 and LWR1/1992/001**	**PN/1985/074 and PN/1987/031A**						**PN/1985/073, PN/1987/031B, FST/1992/008 and FST/1996/110**
Country	**Australia**	**Australia**	**Philippines**	**Australia**	**Philippines**	**Australia**	**Philippines**	**Philippines**
Commodity	**Pineapple**	**Peanut**	**Peanut**	**Mungbean**	**Mungbean**	**Soybeans**	**Soybeans**	**Wood**
Production (000 tonne)	157	27	4	32	24	82	4	11
Consumption (000 tonne)	157	34	536	32	49	134	537	11
Price/tonne	246	370	370	430	894	300	609	78
Elasticity of Supply	0.4	0.3	0.3	0.66	0.66	0.37	0.37	0.6
Elasticity of Demand	0.4	0.41	0.41	0.9	0.9	0.7	0.7	0.4
Year the project started	1985	1985	1985	1985	1985	1985	1985	1985
First year of adoption	1989	1994	1994	1994	1994	1994	1994	2002
Adoption level in first year of adoption	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ceiling adoption level (proportion)	0.6	0.85	0.85	0.85	0.85	0.85	0.85	1.00
Years to ceiling adoption	20	25	25	25	25	25	25	3
Reduction in wastage (%)	na	na	na	na	na	na	Na	na
Change in postharvest cost (A$)	na	na	na	na	na	na	Na	na
Unit cost reduction (A$/t)	5.2	70	73	26	22	30	75	8.6

na = not applicable

Table B5 Data and assumptions used in estimating benefits from crop science research projects based at UPLB, Los Baños (CS1/1991/007, CS1/1990/015, CS1/1994/052, CS1/1996/231, CS2/1991/010 and CS2/1996/091)

Project	**CS1/1991/007**	**CS1/1990/015, CS1/1994/052 and CS1/1996/231**								**CS2/1991/010 and CS2/1996/091**		
Country	**Philippines**	**Australia**	**Philippines**	**Indonesia**	**Taiwan**	**Australia**	**Philippines**	**Indonesia**	**Taiwan**	**Indonesia**	**Indonesia**	**Indonesia**
Commodity	**Papaya**	**Potato**	**Potato**	**Potato**	**Potato**	**Tomato**	**Tomato**	**Tomato**	**Tomato**	**Beef**	**Rubber**	**Palm oil**
Production (000 tonne)	10	1150	65	877	43,266	380	151	302	8,928	325	1,499	4,094
Consumption (000 tonne)	10	1196	99	815	43,589	477	190	310	8759	329	256	2,151
Price/tonne	410	350	343	343	70	538	328	328	328	2085	1,300	31
Elasticity of Supply	0.5	0.51	0.51	0.51	0.51	0.82	0.82	0.82	0.82	0.2	6.6	0.16
Elasticity of Demand	0.76	0.66	0.66	0.66	0.66	0.32	0.32	0.32	0.32	1.08	1.2	0.44
Year the project started	1993	1992	1992	1992	1992	1992	1992	1992	1992	1991	1991	1991
First year of adoption	2002	na	2002	2002	2002	na	2002	2002	2002	1995	1995	1995
Adoption level in first year of adoption	0.25	na	0.05	0.05	0.05	na	0.05	0.05	0.05	0.005	0.005	0.005
Ceiling adoption level (proportion)	1.00	na	0.3	0.3	0.3	na	0.3	0.3	0.3	0.7	0.7	0.7
Years to ceiling adoption	12	na	25	25	25	na	25	25	25	19	19	19
Reduction in wastage (%)	na	na	na	na	na	na	Na	na	na	na	na	na
Change in postharvest cost (A$)	na	na	na	na	na	na	Na	na	na	na	na	na
Unit cost reduction (A$)	74.7	na	20	20	19	na	35	35	35	80	17	1.4

na In Australia, bacterial wilt is adequately managed using crop rotation.