From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

Improved trade in mangoes from the Philippines, Thailand and Australia

IMPACT ASSESSMENT SERIES **50**

Australian Government
Australian Centre for International Agricultural Research

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

Improved trade in mangoes from the Philippines, Thailand and Australia

Michael Monck and David Pearce
Centre for International Economics, Canberra

July 2007

Australian Government
Australian Centre for International Agricultural Research

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

ACIAR seeks to ensure that the outputs of its funded research are adopted by farmers, policymakers, quarantine officers and other beneficiaries.

In order to monitor the effects of its projects, ACIAR commissions independent assessments of selected projects. This series reports the results of these independent studies.

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

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

tel +612 62170500
email <aciar@aciar.gov.au>

Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007.

This report may be downloaded and printed from <www.aciar.gov.au>.

ISSN 1832-1879
ISBN 1 86320 550 0 (print)
ISBN 1 86320 551 9 (online)

Editing and design by Clarus Design
Printing by Elect Printing

Foreword

During 2006–07, the Australian Centre for International Agricultural Research (ACIAR) used a small random-sample approach to choose four projects as the core of its impact assessment studies. This report provides the results of the impact assessments for two of the projects sampled.

Both projects related to the mango industry in the Philippines, Thailand and Australia. One looked at an issue related to on-farm production, by developing a better understanding of flowering to even-out production cycles. The other considered technologies to facilitate trade by developing new methods of treating fruit to meet quarantine requirements in export markets.

The results of the impact-assessment studies were mixed. One project activity generated significant impacts, and the returns to the research were found to be high. The other generated no direct impacts for farmers. These results raised some interesting issues.

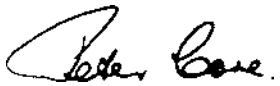
The mango-flowering project chose an area that is a major problem for farmers and the industry in all countries. Like many perennial tree crops, mango yields vary in alternate years. In other industries with similar production characteristics, research has resulted in management strategies that have enabled farmers to effectively even-out production. This is, however, a relatively complex area, so undertaking the initial research is high risk and it may take several projects to fully understand plant behaviour and develop practical solutions.

In contrast, disinfestation of fruit to satisfy quarantine requirements has been common practice for many years. In this case, the banning of chemicals previously used to satisfy quarantine requirements generated the need for new technologies. There were some ideas available, and even a significant set of other research being undertaken or results already available. This area was lower risk and, indeed, one of the important impact-assessment issues was how to attribute the benefits from increased trade to the ACIAR project rather than the other activities.

The return-on-investment estimates reflected the above outcomes. The mango-flowering project was found to have no measurable benefits. Nevertheless, the research groups indicated that subsequent research, funded by other organisations, is still investigating this area, so the start made by the ACIAR project could well be a critical link to achieving a final solution.

For the disinfestation research, the returns of investment were found to be significant. The net present value of benefits was A$20.8 million with a benefit:cost ratio of 5:1 and an internal rate of return of 27%.

This study has generated some interesting issues that will be factored into future decisions about funding research in areas of this type.



Peter Core
Director
ACIAR

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

Contents

Figures

Acknowledgments

The authors extend their thanks to all those who assisted in the preparation of this report. The insights offered by Trevor Dunmall of the Australian Mango Industry Association, and Rod Jordan and Rowland Holmes, both from the Queensland Department of Primary Industries and Fisheries, were invaluable to understanding the industry. The overseas researchers, Udorn Unahawatti, Nipat Sukhvibul (Thailand) and Connie Lizada (the Philippines) also provided valuable information and much appreciated hospitality during in-country visits. Other industry members and research participants also contributed to this report and we offer our gratitude to them as well.

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

Summary

This report undertakes an economic impact assessment of two projects ultimately relating to mango production and trade: CS1/1990/012, 'Flowering behaviour and subsequent productivity in mango', and PHT/1990/051, 'Development of heat treatment systems for quarantine disinfestation in tropical fruit'.

We were able to estimate quantitative economic impacts for the heat-treatment project only. We were unable to find any evidence of economic impacts for the mango-flowering project.

Table 1. Summary of project economic outcomes

	Heat treatment (A$m)	Mango flowering (A$m)
Gross benefits (present value)		
Total	26.3	0.0
Australia	2.4	0.0
Partner countries	23.9	0.0
Total cost of research	5.5	5.3
Net benefits (present value)		
Total	20.8	−5.3
Partner countries only	18.4	−5.3
Benefit:cost ratio		
Total	4.8:1	0
Partner countries only	4.3:1	0
Internal rate of return (%)		
Total	26.7	n.a.
Partner countries only	25.2	n.a.

Source: Centre for International Economics' estimates

Estimates of the broad project outcomes are set out in Table 1.

For the heat treatment project, economic benefits arose through increased trade of mangos with Japan.

Total gross benefits are estimated to be $26.3 million[1], with $23.9 million accruing to the partner countries and $2.4 million accruing to Australia.

After accounting for the project costs of $5.5 million (in present value terms) this leaves total net benefits of $20.8 million, or $18.4 million if only benefits to partner countries are included.

The overall benefit:cost ratio for the project is 4.8:1 (corresponding to an internal rate of return of 26.7%). If only benefits to partner countries are included, this becomes 4.3:1 (an internal rate of return of 25.2%).

1 All dollar values in this report are Australian dollars.

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

1 Introduction

This report provides and impact assessment of two projects ultimately concerned with mango production and trade. Both of these projects were randomly selected for assessment as part of the analysis of the benefits to Australia of ACIAR-funded research set out in Pearce et al. (2006).

CS1/1990/012, 'Flowering behaviour and subsequent productivity in mango', was explicitly concerned with increasing yields in mango production in Australia and Thailand. PHT/1990/051, 'Development of heat-treatment systems for quarantine disinfestation in tropical fruit', while concerned with treatments broadly related to tropical fruits in Australia, the Philippines and Thailand, was, in practical application, mostly concerned with mango trade between the three subject countries and Japan.

CS1/1990/012 sought to investigate why mango yields fluctuate biennially, with an aim of overcoming problems of unpredictable yields. Smoothing yield variability was expected to add certainty to the industry and assist in the development of more reliable markets. Research for this project was carried out in Thailand and Australia and involved personnel from both countries.

PHT/1990/051 recognised that the removal of quarantine constraints on tropical fruit trade, particularly with 'premium' countries such as Japan, could provide potential benefits to each of the partner countries. Research for this project in the Philippines, Thailand and Australia focused on the postharvest disinfestation of fruit using heat treatments that would maintain the quality of the product. The aim of the project was to develop commercially applicable disinfestation schedules by understanding the responses of pests and the effect of the treatment on the fruit.

Chapter 2 summarises the broad inputs, outputs and outcomes for each of these projects, and presents a framework for examining and valuing their economic impacts. Chapter 3 examines mango production and trade in Australia, the Philippines and Thailand, providing most of the base information used for quantifying the benefits of the projects in Chapter 4. Chapter 5 draws the conclusions of the study.

2 Inputs, outputs and outcomes

The projects

Table 2 provides a broad summary of the two projects, and Table 3 presents basic budget information for each project. The broad flows of benefits for each project, from inputs to outcomes, are summarised in Figures 1 and 2.

Mango flowering

The problem

Mango growers suffer from unpredictable output characterised by annual fluctuations in yield and quality. Yield fluctuations impact on farm incomes as well as affecting other participants in the value chain, and consumers. Marketing, planning and pricing efforts are made more difficult because of the variability in production.

Table 2. Summary of the two projects

Details	One hundred word summary
CS1/1990/012: Flowering behaviour and subsequent productivity of mangoes **Partner country**: Thailand **Commissioned organisation**: Queensland Department of Primary Industries **Collaborating institutions**: Department of Agriculture, Thailand; CSIRO Division of Horticulture, Australia. **Duration**: June 1994 to July 1999	Both Australia and Thailand have extensive mango industries, but changeable seasons cause fruit yields to fluctuate up to 150% from year to year. Consistent levels of flowering and fruit-set are paramount to sustaining high and reliable yields, and this project will investigate how environmental factors such as water supply and temperature affect the initiation of flowering. Next, researchers will study how cold temperatures affect the fruit-development steps of pollination, ovule fertilisation and embryo development in Australian and Thai cultivars. These studies will identify cultivars more suited to specific growing regions. Ultimately, the knowledge gained will lead to practices that substantially improve mango production.
PHT/1990/051: Development of heat-treatment systems for quarantine disinfestation in tropical fruit **Partner countries**: The Philippines and Thailand **Commissioned organisation**: Queensland Department of Primary Industries **Collaborating institutions**: Bureau of Plant Industry, Philippines; Thailand Institute of Scientific and Technological Research **Duration**: July 1991 to July 1995	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 seeks 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. This will eventually open up new export markets for South-East Asian countries and Australia.

Source: ACIAR project documents

The research aims for this project were to smooth-out fluctuations in production. This was expected to allow for easier negotiation of long-term contracts and to increase certainty within the industry. More regular supply was also expected to increase the ability of growers and marketers to penetrate new markets.

The research

The project had the clearly stated objective (Whiley 1997):

> to improve the sustainable production of mango cultivars growing in the sub-tropical and tropical environments of Thailand and Australia so that domestic and export markets could be reliably serviced with quality fruit yielding higher financial returns to growers.

Research was conducted into the relationship between the flowering behaviour of different mango varieties and their fruit yield. This was expected to enable scientists to determine those varieties most suited to the different regions covered by the project.

Outputs

Outputs of the project included journal articles, conferences and seminars. Like many projects, a great deal of scientific knowledge has been gained during the research, and several technical measurement techniques have been developed, most notably in the area of sap-flow measurement.

The project review report (Whiley 1997) found that:

> …the problems of erratic flowering and low productivity had not yet been solved, although a better understanding of the contributory factors has undoubtedly been generated.

A large amount of this knowledge is being used in research begun after the initial project. The sap-flow measurement technique has been used in research undertaken in Canada and the Northern Territory of Australia. This implies that there is a possibility of capacity-building benefits and that it would be appropriate to attribute some of the benefits of future research outcomes to the research undertaken in this project. Recent analyses of capacity building (see, for example, Gordon and Chadwick (2007)) have indicated that they may be significant. The capacity-building benefits of this project were discussed qualitatively in Pearce et al. (2006).

Benefits

Most researchers involved in the project believe that the applied economic benefits of the research in terms of improved production techniques are yet to be realised. The nature of the outputs means there are few, if any, tangible changes and little adoption of new growing or marketing techniques as a consequence of the research.

Table 3. Project budgets

Year	**CS1/1990/012 Flowering behaviour of mangoes** Current dollars	**PHT/1990/051 Heat-treatment systems** Current dollars	**Deflator** 2004=100	**CS1/1990/012 Flowering behaviour of mangoes** Constant 2004 dollars	**PHT/1990/051 Heat-treatment systems** Constant 2004 dollars
1991		954,177	76.6		1,246,170
1992		722,782	77.8		928,450
1993	955,865	684,698	78.8	1,213,463	869,218
1994	818,113		79.4	1,030,726	
1995	809,284		80.8	1,001,217	
Present value in 2004[a]				5,307,594	5,503,861

[a] Here and elsewhere we have used 2004 as the common point of comparison for all time-series variables. That year is the last year of complete data for actual exports to Japan and is also the year around which the premium calculations are based.

Source: ACIAR project documents. Deflator taken from Gordon and Davis (2007).

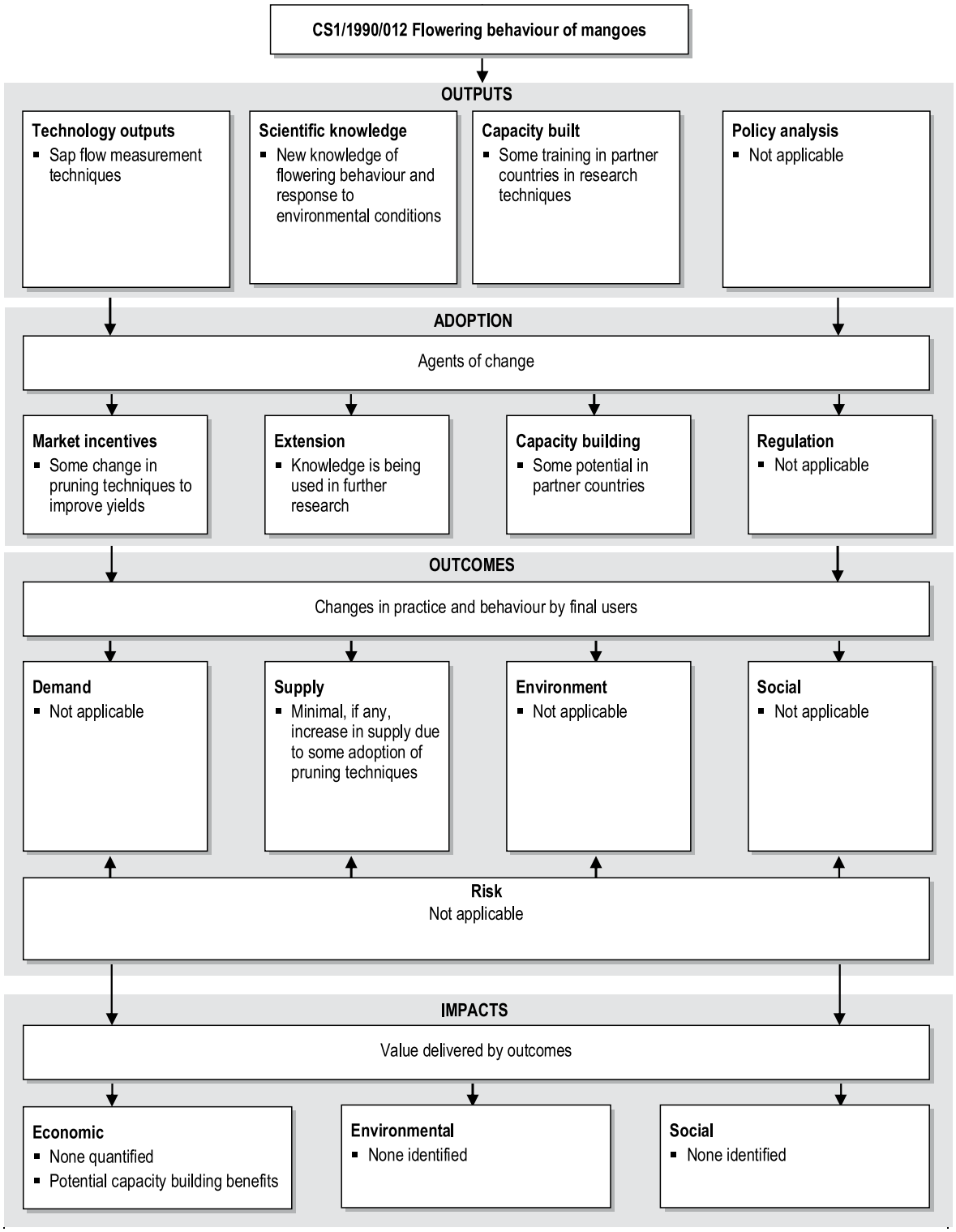


Figure 1. Flow of outputs and outcomes for project CS1/1990/012, 'Flowering behaviour of mangoes'

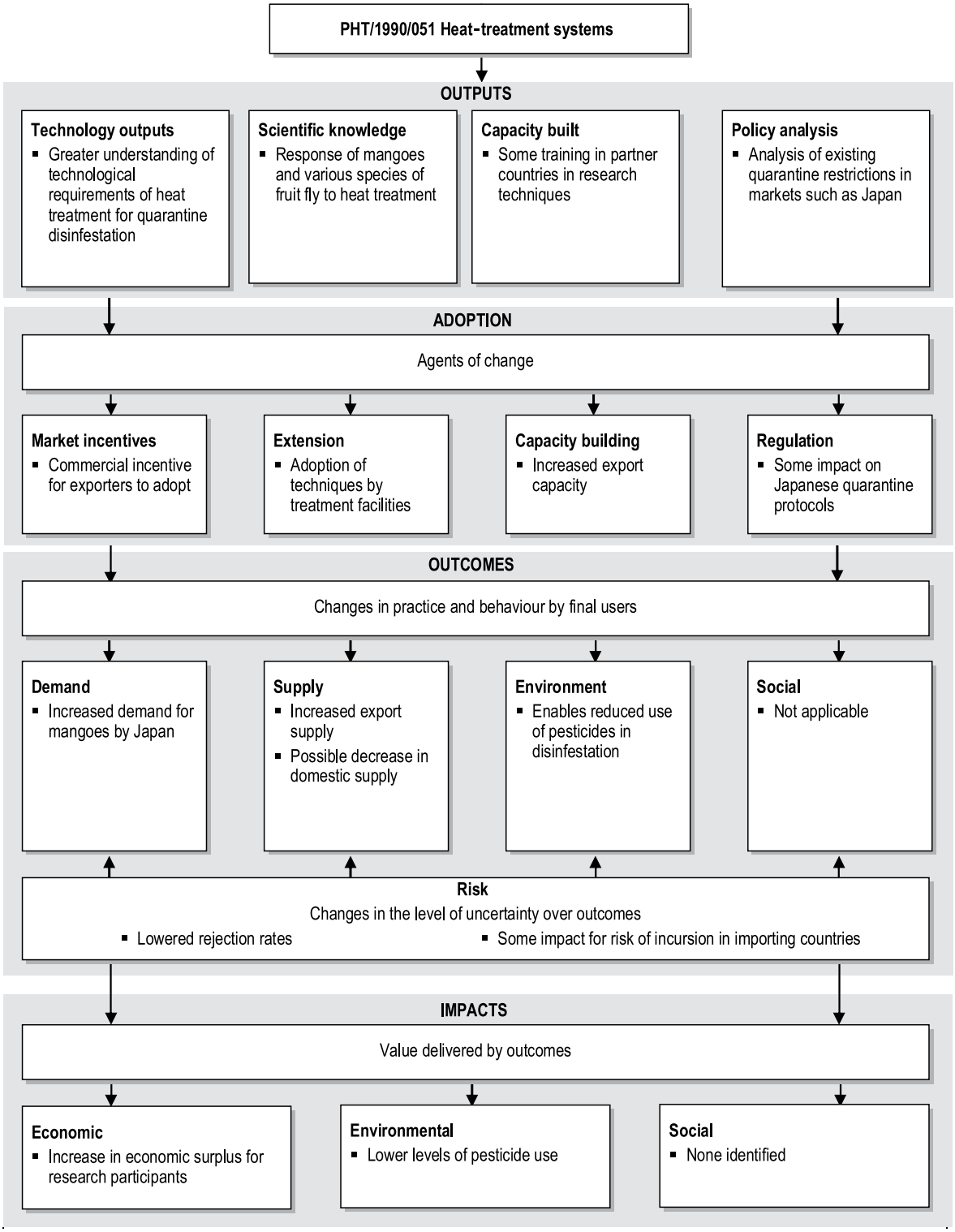


Figure 2. Flow of outputs and outcomes for project PHT/1990/051, 'Heat-treatment systems for tropical fruit'

While the project findings have led to more research, they have not led to outcomes in terms of changes in farm management, harvesting, and so on.

Some Thai researchers involved indicated that little change has, in fact, taken place. At best, existing growers may be a little more attentive to pruning, while new growers are better able to select ground with more suitable growing conditions.

Conclusions

As a consequence of this, we have been unable to quantify any production or marketing impacts of this project. Until further evidence becomes available, we assume that these benefits from the project are zero. It is important to note, however, that there may be some capacity-building benefits that have emerged, or will emerge, as a consequence of other research projects that we have not quantified here.

Heat disinfestation

Although they are predominantly designed to prevent the transmission of disease and pests, quarantine restrictions are also a significant impediment to trade. The work under PHT/1990/051 aimed to overcome some of these constraints by developing a schedule of treatments known to disinfest tropical fruits from known pests, namely the oriental fruit fly found in parts of South-East Asia and the Queensland fruit fly found in northern parts of Australia. These pests are not found in major destination market countries, including Japan, the USA, New Zealand and Europe (although Europe does have the Mediterranean fruit fly).

The oriental fruit fly is arguably the most destructive of the fruit-fly family and can be found throughout South-East Asia, Hawaii and South America. The Queensland fruit fly is found in Australia and is considered to approach oriental fruit fly in terms of seriousness as a pest. The presence of these pests clearly affects the ability of these countries to export fruit to other importing nations. To compound matters, Japanese and US authorities require each country to prove its disinfestation procedures on a fruit-by-fruit, and pest-by-pest basis.

In the years before the ACIAR-funded project, treatment with a chemical, ethylene dibromide (EDB), was used and accepted as an effective means of disinfestation. In the mid to late 1980s, this treatment was phased-out in many developed countries amid health concerns. Heat treatment of fruit was considered as an alternative procedure that may be suitable.

Vapour-heat treatment (VHT) was first used commercially in Florida in 1929 where it was applied to rid citrus fruits of Mediterranean fruit fly. Since then, other treatments have been developed for Hawaiian papaya, Japanese green peppers, melons, mango and eggplant in countries including Mexico, the Philippines, Taiwan and Thailand. The treatment typically involves heating the fruit by subjecting it to forced airflow at around 90% relative humidity for 2–4 hours. This raises the core fruit temperature to around 46 ° Celsius for about 10 minutes. The treatment can lead to damage to the fruit as a result of vapour condensation. This has led to the development of reduced humidity heat treatment (RHHT), commonly referred to as hot-air treatment. The method is similar to VHT but uses a relative humidity of only 80%.

A third method of heating fruit, hot-water treatment, sees the fruit immersed in hot water tubs for an extended period. In terms of capital and operating costs, it is the least expensive way to heat fruit, but it does entail losses from fruit damage, because of the longer treatment times required.

One of the most lucrative export markets requiring disinfestation treatment is the Japanese mango market. Consumers in this market pay significantly higher prices than those achievable elsewhere, resulting in substantial rewards available to those producers and importers able to participate in the trade.

Having had a long history of mango exports to Japan, the Philippines was keen to maintain this trade despite the banning of EDB in 1986. They instituted the use of VHT on mangoes and, in 1988, it was accepted by Japan as an effective means of eradicating fruit flies from mangoes (Lantican 1997). Thailand followed suit, and collaborated with the Philippines and Japan on a project funded by the Japanese International Co-operation Agency (ACIAR 1990). This funding provided substantial amounts of equipment and manpower used to develop mango-disinfestation treatment schedules.

Many other organisations in other parts of the world have undertaken or are currently taking part in research into heat treatment for quarantine purposes. The work has involved ACIAR, CSIRO, the Queensland Department of Primary Industries and other state government agencies in Australia, and the Division for Scientific and Industrial Research and the Ministry of Agriculture and Finance in New Zealand. Some of the work is based on previous US research into RHHT while others have pursued the further development of Japanese research into VHT. The long-standing involvement of Japan in this area can be seen, for example, in Kitigawa et al. (1990. The diverse heat-treatment findings before the ACIAR-funded project are documented, for example, by Kuo (1988). Examples of ongoing research (subsequent to the ACIAR-funded project) include Corcoran et al. (2002).

Research

ACIAR commissioned the Queensland Department of Primary Industries (QDPI)[2] in Australia to undertake the research. QDPI then partnered with the following agencies and organisations in the Philippines and Thailand:

- Agricultural Regulatory Division, Department of Agriculture, Thailand
- Thailand Institute of Scientific and Technological Research
- Postharvest Horticulture Training and Research Centre, University of the Philippines, Los Baños
- Bureau of Plant Industry, the Philippines.

Figure 3 shows the project broken into two subprograms—entomology and fruit quality. The entomology subprogram dealt with the issues surrounding the disinfestation of the fruit, while the fruit-quality program examined the effects that the heat treatment had on the fruit in terms of damage. The purpose of the two subprograms was to optimise the heat-treatment schedules to maximise pest disinfestation while minimising damage to fruit. Factors such as the type and size of the fruit, its density and maturity, and the pest species targeted, were considered in order to increase the applicability of the schedules. The approach used in the research saw multidisciplinary collaboration between entomologists, plant physiologists and plant pathologists, to ensure the aims could be met and thereby allow the overall project objectives to be achieved.

While the ACIAR-funded research can be used to define schedules of treatments, and explore the technology requirements for suitable heat-treatment equipment, it is up to third parties to utilise the information. Importing countries must adopt the knowledge contained within the schedule when drawing up quarantine protocols, while a commercial entity is probably best positioned to utilise the technological requirements. Equally important is that exporting countries must use the treatment schedules when drafting proposals and submissions for exports during the negotiation process. It is the adoption by these third parties that ultimately led to benefits being realised.

Objectives

The main objectives of PHT/1990/051 were:

- to harmonise heat treatment for quarantine disinfestation procedures across countries
- to improve the efficiency of the development of specific disinfestation protocols
- to increase the understanding of the technology requirements for effective heat treatment.

The definition of broad heat-treatment parameters that are non-injurious to fruit but maintain an acceptable level of disinfestation allows schedules to be developed that apply to many fruit and pest combinations. Such schedules are designed to eliminate the need for detailed replication of previous research when assessing the suitability of certain treatments for quarantine purposes. At worst, the project results were expected to reduce the time required for the development of a suitable protocol, if the importing country did not deem the treatments resulting from the research as suitable for quarantine purposes.

Better understanding of the requirements for effective heat treatment was also expected to lead to the development of more efficient and less expensive equipment for use in the treatment process. At the time of the project proposal, two companies, one with expertise in high humidity air systems for horticulture and another with general engineering capabilities, had expressed an interest in developing new heat-treatment systems.

2 Now the Department of Primary Industries and Fisheries

Outcomes and benefits

The major benefit that emerged from this project was a net increase in mango-producer income as a result of increased trade with Japan—in particular, trade at a premium price. The nature of this benefit will be examined in more detail below, but there is evidence that, over time (since the project was completed), there has been an increase in gains from mango trade with Japan. However, the crucial question for this impact assessment is the extent to which these observed gains (and any potential future gains) can be attributed to the ACIAR-funded research.

Aside from being involved in the negotiation of market access for Australian mangoes, the project ended at the research stage and did not extend to getting the treatment schedules accepted for quarantine purposes or the development of commercial treatment equipment for sale.

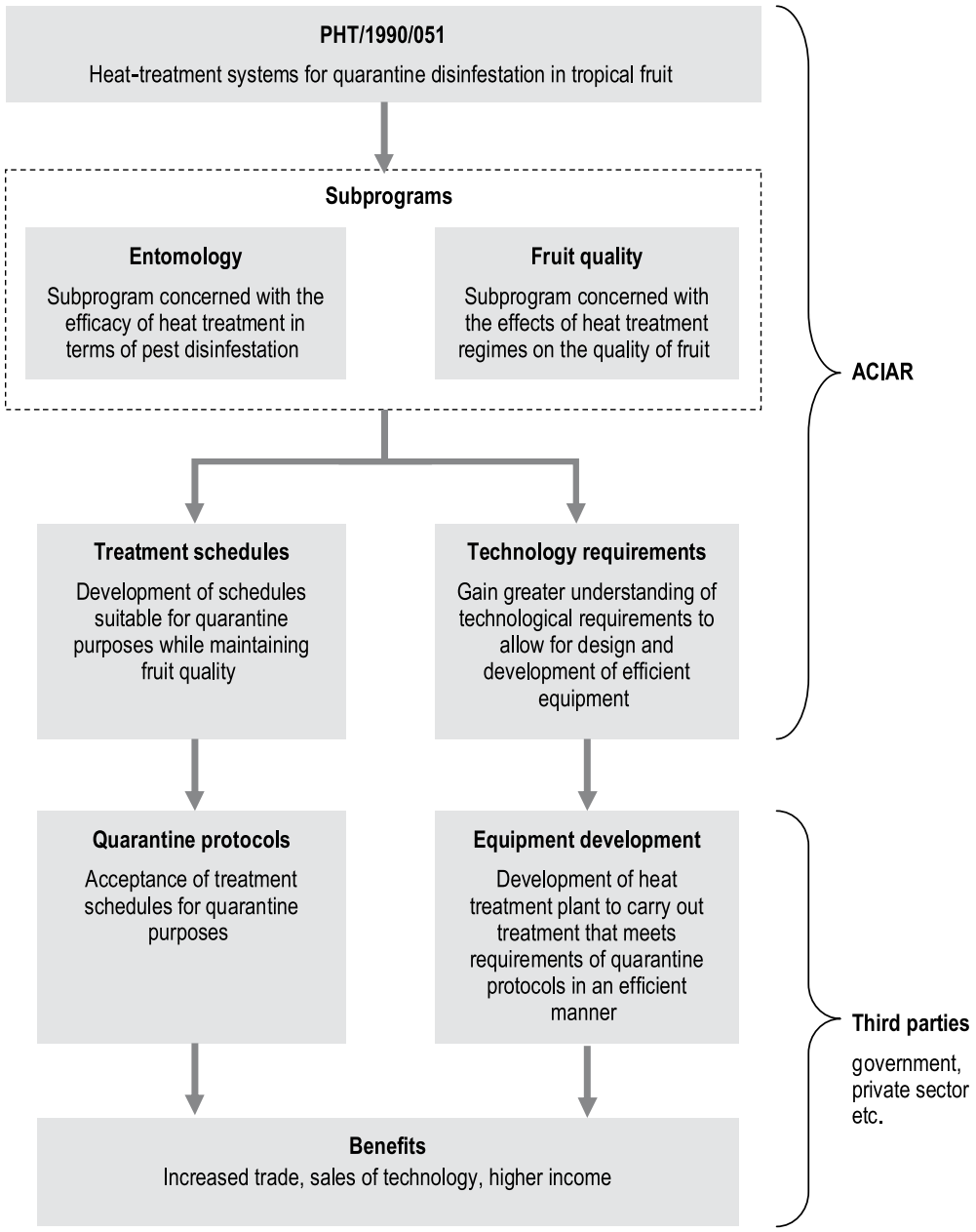


Figure 3. Project flow of PHT/1990/051

The Philippines has maintained its trade with Japan throughout the period of the research and beyond but, given that it began VHT treatment before the beginning of the project, it is difficult to say what influence, if any, the project findings had in the Philippines. It would certainly not be appropriate to attribute the majority of the benefits of the Philippine trade with Japan to the ACIAR-funded project.

Similarly, Thailand was involved in projects with the Philippines and Japan that were exploring heat-treatment options before the commencement of PHT/1990/051. Despite this, Thai mango exports to Japan were quite limited until 1994, at which point they experienced a sharp increase. In light of the previous research, attributing this wholly to the ACIAR project would be not be appropriate but, in this case, it would be justifiable to attribute some of the benefits to the ACIAR-funded research. While another sharp increase in Thai mango exports was experienced in 2003, with the passage of time and the research that has subsequently taken place, it would be appropriate to attribute a declining proportion of the benefits of this trade to the original ACIAR-funded research (see below)

For Australia the attribution of benefits may be clearer. As part of the project market access was negotiated with Japan for the season of 1994–95. Despite a setback throughout 1995–96 due to a fruit fly outbreak in Queensland that saw market access withdrawn, exports were re-approved in December 1996 and have grown since then. However, it is important to note that, since the completion of the original ACIAR-funded research, many Australian organisations have been continuously involved in securing and maintaining mango access into Japan. They include the Queensland Department of Primary Industries and Fisheries, Horticulture Australia Limited (along with the Australian Mango Industry Association), the Commonwealth Department of Foreign Affairs and Trade, and the Australian Trade Commission.

The nature of the economic benefits

A premium price in Japan?

As noted, the major economic benefit of this research is to allow trade in mangoes with Japan. The volumes traded into Japan are, however, very small, and the gains from trade from these volumes alone are also likely to be very small. The real benefit comes from the fact that the Japanese market attracts a 'premium' price for mangoes. It is therefore crucial to understand the nature of this premium and the way in which it leads to benefits to exporting countries.

While it is very difficult to observe prices for mangoes sold into Japan (mostly due to commercial in-confidence arrangements), there is some evidence (discussed further below) that the export (free on board) and farm-gate prices of mangoes sold to Japan are higher than prices on either the domestic market or on other export markets.

The underlying source of this premium is the fact that exports to Japan are limited by quarantine restrictions and, in particular, the way in which Japan goes about imposing these restrictions. Even though there are quarantine treatments available, the total quantity of imports is limited by the availability of Japanese inspectors who are required to be present in the country of origin. The restricted quantity naturally means that prices are higher in the Japanese market than elsewhere. The 'premium' is, in effect, the tax equivalent of the Japanese quarantine system.

The whole of this premium, of course, does not necessarily accrue to mango growers. Some of it will be taken as a return to:

- the ability to import (that is, there are likely to be rents to importers that can arrange access)
- the capital used to establish the treatment plants
- the higher quality of fruit needed for access to the treatment plant
- the cost of treatment itself
- risk associated with the Japanese market.

What remains is likely to be available to producers. In Chapter 3, we set out some estimates of the Japanese premium for Australia, Thailand and the Philippines.

The net economic benefit of exports to a premium market

In the analysis that follows, we treat the benefit of the project outcomes as being equal to the full amount of the gains from trade with Japan.

These benefits could be treated as a decline in transactions costs in undertaking trade, where quarantine procedures are a part of the relevant transactions costs. Such an approach would lead to an estimate of the marginal increase in net economic benefits as a result of lowering the transactions costs. The data for this type of analysis were not easily available, however, so we have approached the estimation of benefits as a matter of calculating the changes in consumer and producer surplus as Japan is added to (or taken away from) the market.

The addition of Japan to the market is an increase in demand facing the local producer. Panel I of Figure 4 illustrates the typical effect of an export demand increase. This is similar to chart 5.2 of Gordon and Davis (2007). As Gordon and Davis point out, if the initial demand curve (D) is equal to domestic demand, then the net gain from the increase in demand is equal to the shaded triangle *abc*, which is the difference between the domestic producer gain (P_1abcP_J) and the domestic consumer loss (the shaded area P_1acP_J).

In the case of mangoes, however, access to the Japanese market at a premium price is not really an increase in the whole demand schedule. The premium is itself intimately related to the existence of the quarantine restriction. Without the implicit quantitative constraint on trade imposed by the quarantine system, the premium would not exist. More precisely, the premium would be fully explainable in terms of a higher-quality product, or better service, and so on. Access to the Japanese market in this case is in effect an offer (to the domestic producer) of the purchase of a fixed quantity at a fixed premium price. Importantly, the premium is applicable to only the Japanese quantity.

This is illustrated in panel II of Figure 4, which shows a case where the fixed demand from Japan (equal to the quantity $Q_1 - Q_0$) at a premium price (where the premium is $P_J - P_W$) leads to a reduction in supply to other markets (which, in this illustration, are assumed to have perfectly elastic demand). Initially (before Japan enters the market), demand is perfectly elastic at the world price (P_w) and total supply is Q_1. Japan then enters the market (as a result of the quarantine treatment) and offers a fixed quantity of sales at price P_J. As a consequence, sales to other markets (these could be the domestic market or other export markets, but are represented here as a single curve) fall to Q_0. Initially, producer surplus was equal to P_0aP_w, but following the Japanese premium it becomes P_0edP_w plus *ecba*. This is a net gain of the shaded area *abcd*. In this special case (with no consumer loss and no supply response—see below) the net gain is equal to the Japanese premium multiplied by the quantity sold to Japan.

Panel III of Figure 4 shows a case where there is some downward slope in the initial demand curve (again representing aggregate 'non-Japanese' demand). With the Japanese fixed-quantity demand at a premium, and again assuming no supply response, there is, as a consequence, reduced supplies on the non-Japanese markets associated with an increase in the price in these markets. The net gain to the producer is now equal to the two shaded areas: the gain from the Japanese premium, and the gain from the higher price on the other markets (with a lower quantity).

It is important to note that not all of the increase in producer surplus is, in fact, a net economic gain to the country, because some of this increase in surplus will come at the expense of domestic consumers. This is illustrated in Figure 5, which illustrates the domestic-demand component of total supply. In this case, the loss of the domestic consumer surplus is the darker shaded area and must be taken off the producer gain in order to estimate the net economic benefits to the country.

In each of these illustrations we have assumed that total supply remains fixed. This is, of course, not necessarily true. If supply depends on the premium price and the usual price in domestic and other markets then there will be a supply response. This will tend to reduce the consumer losses.

We can capture these features of the market with the following standard net trade model (expressed here in linearised form). Total supply is the sum of the supply to Japan, to other markets and to the domestic market (equivalently, exports are the excess of supply

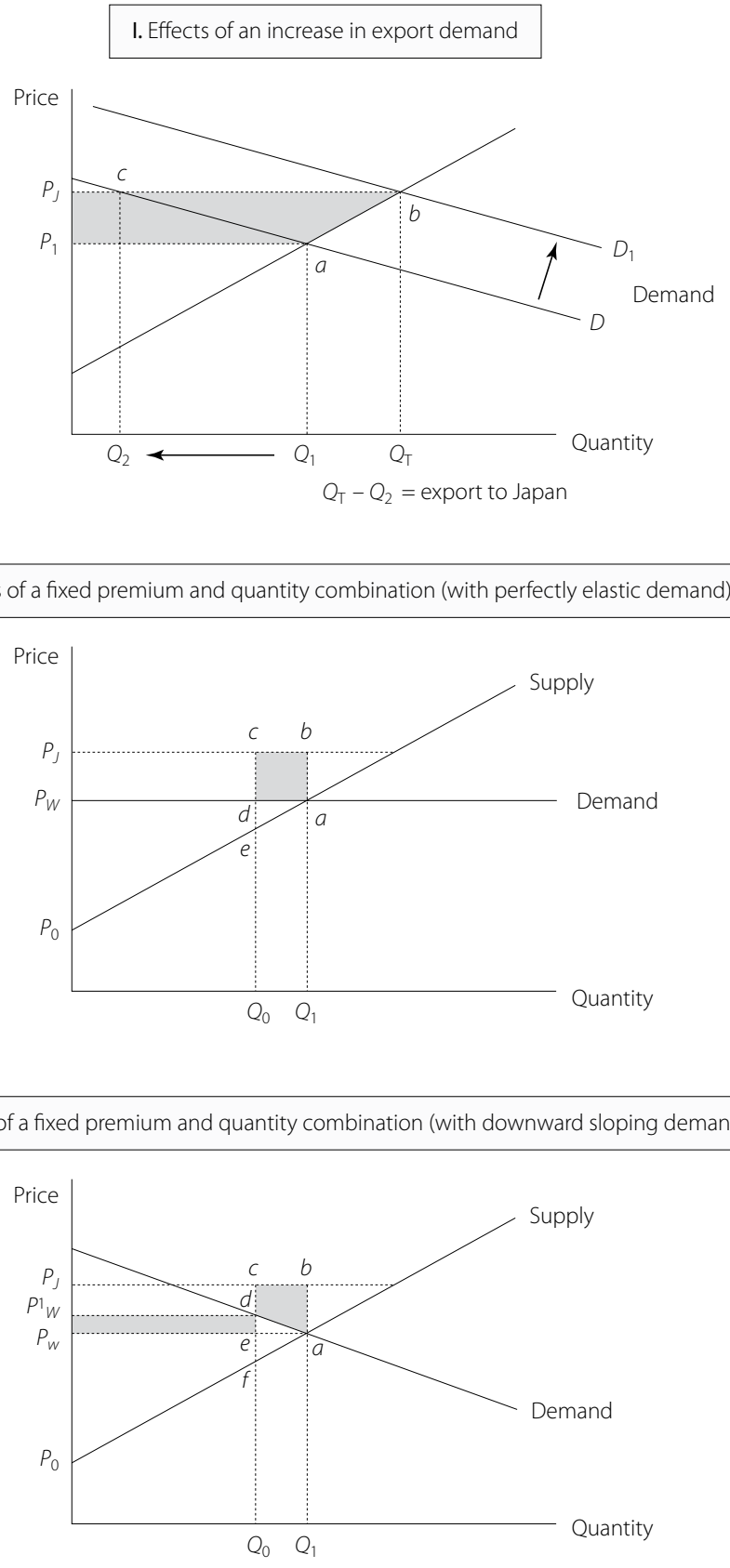


Figure 4. Effects of increased exports of mangoes to Japan. Data source: Centre for International Economics

over domestic demand at a given price). Demands all depend on prices (except in the case of Japan, see below) and total supply depends on the weighted price between Japan and other markets. The price received from the Japanese market is at a fixed premium to the world price.

$s = S_J x_J + S_O x_O + S_D d$	total market supply
$x_O = \gamma p_O$	exports to other markets
$d = \eta p_O$	domestic demand
$s = \tau(S_J p_J + S_{OD} p_O)$	supply
$p_J = p_O + \pi$	price received for Japanese exports

Here:

- s is the change in supply
- x_O is the change in exports to other markets
- d is domestic demand
- x_J is exports to Japan
- p_J is the price received from the Japanese market
- π is the Japanese premium (as a percentage change variable—this is 1 plus the rate of the premium).
- p_O is the price in other markets (assumed the same for domestic and other export)
- S_J is the share of Japanese exports in total supply
- S_O is the share of exports to other countries in total supply
- S_D is the share of domestic consumption in total supply
- S_{OD} is the share of other markets and domestic demand in supply
- γ is the export demand elasticity in other markets
- η is the demand elasticity in the domestic market
- τ is the supply elasticity.

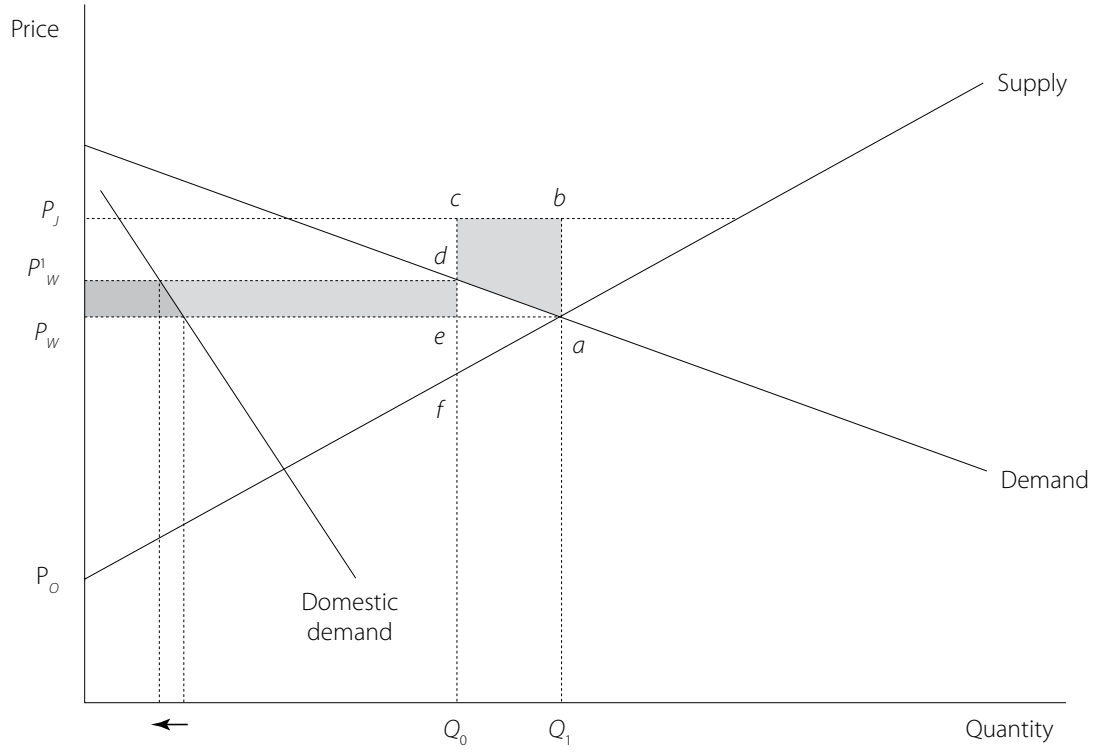


Figure 5. Effects of demand increase, including domestic consumer loss

The variables x_J and π are exogenous to this system. We can simulate the effect of adding or removing Japanese exports at a premium by changing these exogenous variables by an appropriate amount. Using this, we can calculate the change in domestic price as a result of the change in Japanese demand and, therefore, track changes in domestic quantities.

The discussion in chapters 3 and 4 provides the base data for this system.

Attribution of benefits to the project

As noted, the approach broadly outlined above provides an estimate of the total benefits of trade with Japan. In order to value the ACIAR-funded research, we need to attribute some, or all, of these benefits to the project itself.

The guidelines for evaluating research and development set out in Gordon and Davis (2007) make some recommendations about the treatment of attribution according to whether the project outputs were necessary but not sufficient, sufficient, or neither necessary nor sufficient, to determine the identified outcomes.

In this case, the project outputs were neither necessary nor sufficient for the identified benefits (trade with Japan) to emerge. Indeed, adoption of the project's findings required significant action on the part of others, including commercial firms and Japanese authorities. This means that full attribution of the benefits to the project is not appropriate. Rather the project falls into Gordon and Davis's category of 'marginal contribution', signifying the project raised the magnitude of the impact. We implement this by applying an attribution proportion to the benefits in each year. This proportion is less that 1 (for the reasons outlined above), and is multiplied by the total benefits to give an estimate of the benefits attributable to the project. This proportion is assumed to decline over time. As the amount of other research, promotion and so on increases over time, the relative marginal contribution of the original project declines.

3 Mango production, prices and premiums

The mango industry varies greatly in each of the partner countries. Production in Thailand is by far the greatest, but the Philippines leads the way in terms of exports. Australia is the smallest producer and exporter of the three countries. Before the research, the Philippines had already gained access to the Japanese markets and its level of exports to this destination has remained relatively constant since 1988. Both Australia and Thailand experienced substantial growth from 1994 to 2003 with much higher growth for Thailand.

Figure 6 shows the growth in Japanese mango imports from the collaborating countries, and from Mexico, China and the USA. Each of these countries is either a significant producer of mangoes in world terms or a producer of significance to Japan.

India, the world's largest producer of mangoes, has also been granted access to the Japanese markets and delivered its first shipment to Japan in May 2007. Although the shipment amounted to around only 35 tonnes, it is expected that this will rapidly grow and introduce competition in Japan.

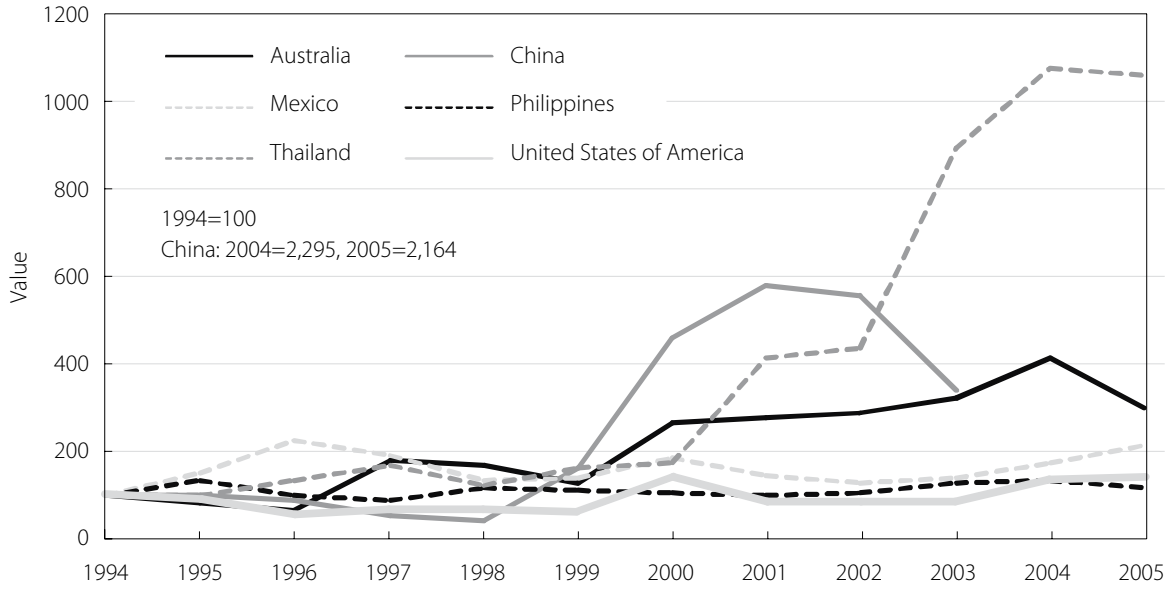


Figure 6. Growth in Japanese mango imports. Data sources: Food and Agriculture Organization; Australian Bureau of Statistics

Thailand

According to the Australian Mango Industry Association, Thailand was the world's third largest producer of mangoes in 2002. India and China, the two largest growers, produced 11.4 million tonnes and 3.1 million tonnes, respectively, while Thailand produced 1.75 million tonnes.

Thailand is an accomplished exporter, with customers in many regions of the world including Asia, Europe and the Middle East. As with the other partner countries, Japan is the most important importing country that requires heat treatment. Table 4 shows that, over the period 2000–05, exports have increased markedly, more than doubling in 2003. In the last three years for which data are available, Thai exports have averaged 1,133 tonnes annually.

The Philippines

Like Thailand, the Philippines is an exporter of mangoes and has been for some time. Japan has been a major importer of Philippine mangoes since well before the project began, but has experienced some quarantine problems.

In 1973, many countries banned imports from the Philippines due to the detection of fruit fly and mango weevil. Japan lifted the ban in 1975, but insisted all exports be treated with EDB. The use of EDB was banned in 1986 in response to concerns that it might be carcinogenic, but it was only two years until exports resumed again in 1988, when Japan deemed VHT to be a suitable method of treatment.

Since that time, exports to Japan have exhibited very little volatility in terms of quantity. Table 5 shows exports for the period 2000–05, over which exports have averaged around 6,150 tonnes annually, with very slight, but perceptible, growth.

There are five plants in the Philippines, all of which have been in operation since before 1990. Figure 7 shows the main period of growth in mango exports for the Philippines occurred between 1990 and 1991. Aside from this brief spurt, exports have remained relatively steady, even after the research was completed. The existence of exports that pre-date the project and the lack of growth since would make any attribution of the trade itself to the ACIAR projects questionable at best. The most likely benefit would come from potential costs savings that arise from optimising the heat-treatment process.

Australia

Estimation of the true size of the Australian mango industry is difficult due to conflicting data sources. The main sources of data—the Australian Bureau of Statistics, the Queensland Department of Primary Industries, the Australian Government Department of Agriculture, Fisheries and Forestry, and industry organisations—all differ in their estimates. The analysis

Table 4. Thailand exports of mangoes to Japan

Year	Exports (tonnes)
2000	194
2001	460
2002	487
2003	1,002
2004	1,206
2005	1,192

Source: Food and Agriculture Organization

Table 5. Philippines exports of mangoes to Japan

Year	Exports (tonnes)
2000	5,618
2001	5,397
2002	5,601
2003	6,746
2004	7,303
2005	6,275

Source: Food and Agriculture Organization

in this paper rests on production and trade data from the Australian Bureau of Statistics (ABS) and the Food and Agriculture Organization of the United Nations (FAO). The most important data for the analysis here are the trade data, and we use the ABS to ensure a consistent treatment (through FAO) of total imports into Japan.

Most Australian mango production, around 80% in recent years, is in Queensland. Table 6 shows that this has been the case since the 1990–91 financial year. Western Australia has seen production increase tenfold over the period 1990–91 to 2003–04 while Northern Territory production has had a sixfold increase. In contrast, Queensland growth has been somewhat smaller, but it is still by far the dominant producing region in Australia.

Japanese imports of Australian mangoes were nonexistent before 1994, at which time Australia was granted market access using VHT for quarantine treatment. Shortly after this, a fruit-fly outbreak occurred in Queensland and exports declined to a low of 75 tonnes in 1996. In December that same year, market access was again granted (still requiring VHT) and exports, while remaining variable, have since grown on average. Table 7 reports the exports from their start in 1994 through to 2005.

Price premiums available to producing countries

The Japanese market appears to attract a premium, making it an appealing proposition for exporters. This premium is created partly because of the quarantine requirements in Japan.

The quarantine legislation requires that a Japanese inspector be present during the entire treatment and packing stages. This not only adds costs to the process but also, due to the limited availability of inspectors, restricts the ability of producing countries to export. This increases the price in two ways.

First, the limited availability of inspectors directly restricts the amount of product that a country can export. If no inspectors are available to inspect the treatment and resulting shipment, then exports cannot proceed regardless of the underlying supply of mangoes.

With no quantitative import restrictions from quarantine requirements, the price in Figure 8 would be *PW*, the world price, while the quantity imported into Japan would be *Q* (for this illustration, *D* is Japanese demand for mangoes and we ignore the very small domestic production). By restricting the number of

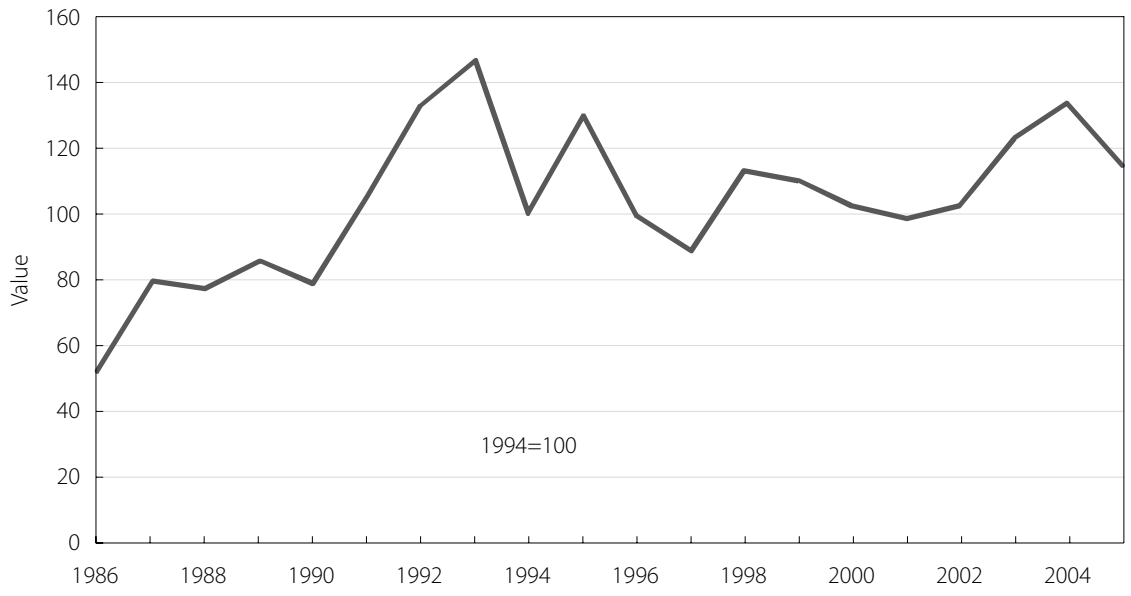


Figure 7. Philippine exports of mangoes to Japan. Data source: Food and Agriculture Organization

Table 6. Australian mango production (tonnes) by state

Season	New South Wales	Northern Territory	Queensland	Queensland percentage of total production	Western Australia	Total
1990–91	331	1,003	10,303	88	281	11,918
1991–92	183	2,020	11,756	81	568	14,527
1992–93	139	4,211	26,084	83	566	31,000
1993–94	117	3,897	18,799	78	1,400	24,213
1994–95	–	5,530	30,612	81	1,575	37,717
1995–96	–	5,666	20,445	74	1,607	27,718
1996–97	273	2,668	28,366	88	1,095	32,402
1997–98	–	–	–	–	–	36,567
1998–99	–	–	–	–	–	26,372
1999–2000	–	5,244	30,770	81	1,922	38,071
2000–01	386	6,718	28,233	75	2,060	37,398
2001–02	259	6,071	32,361	79	2,281	40,973
2002–03	260	6,704	29,300	75	2,706	38,970
2003–04	433	6,027	28,516	77	2,192	37,169

Sources: Australian Government Department of Agriculture, Fisheries and Forestry; Australian Bureau of Statistics

inspectors available, the supply of mangoes into Japan is also restricted. The quantity of mangoes imported falls to Q_R, while the price that consumers in Japan face rises to P_D. The difference between P_D and P_W is an implicit tax on Japanese consumers. Some of this 'tax revenue' or, equivalently, the rent from the quantitative restriction, is available to exporters. However, this premium rent will be available only to exporters that have access to an inspector and this is not always the case, even when you have been granted access to Japanese markets.

If a producer cannot be guaranteed that an inspector will be available, then they may choose not to engage in the trade. Those producers that do choose to participate in the Japanese market will charge a 'risk premium'. This premium will compensate for the chance that the shipment has to be diverted to other markets should the exports be prevented from going ahead.

In March 1996, Thailand lodged with the Market Access Ombudsman Council in Japan a complaint about the inspectors (CAO 2007). Thailand exports to 12 countries, but the only one that requires an 'in plant' quarantine

Table 7. Australian exports of mangoes to Japan

Year	Quantity (tonnes)
1994	115
1995	91
1996	75
1997	207
1998	193
1999	146
2000	301
2001	318
2002	330
2003	370
2004	475
2005	343

Source: Food and Agriculture Organization

inspector is Japan. The other countries allow imports based on certification issued by the Thai Government. The extra costs associated with the Japanese inspectors are borne by Thailand which raises its export costs. There is also the concern that, if Thailand were to construct additional treatment facilities, Japan would not assign sufficient inspectors to oversee the extra production, thereby increasing the investment risks. In April of the same year, Japan decreed that the inspectors would remain, despite Thailand's concerns.

There are various costs involved in obtaining the Japanese premium. One of these is the increase in packaging and labour costs. Treated fruit must be packed in materials that prevent reinfestation. This packaging consists of modified boxes that are screened with mesh to prevent insects gaining access to the fruit. Extra padding in the form of a plastic-foam, mesh 'sock' is also applied to each mango to prevent damage while the fruit is in transit. The packing and treatment times take longer than those for standard domestic products and the labour costs per hour are higher, because the personnel require additional training.

In addition, exports require the establishment of a heat-treatment facility which will involve a capital cost.

Thailand

Calculations underlying the premium available to Thai producers are set out in Table 8. Discussions with the Department of Agriculture in Thailand have revealed the average price of mangoes to be in the order of $1.30 per kilogram in recent years. The export price of mangoes to Japan has been estimated to be in the range of $5.32–$6.38 (estimates provided by the Queensland Department of Primary Industries and Fisheries). This suggests an initial premium of $4.55 per kilo. From this must be taken packaging and fruit-loss costs (including labour and materials) of $0.90 per kilogram (Thailand Department of Agriculture, pers. comm.), capital costs and a risk premium.

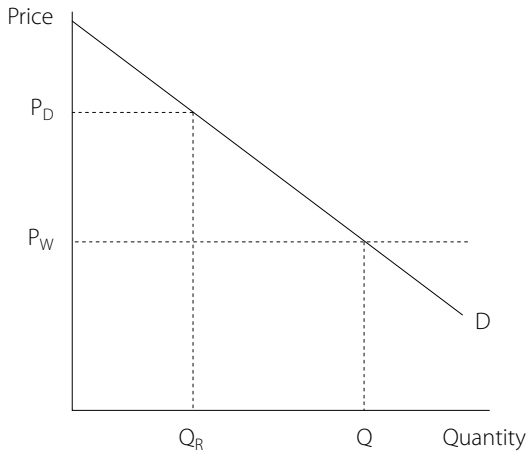


Figure 8. World price versus Japanese price

Capital costs are calculated as follows. We estimate capital expenditure on heat-treatment plants since the project was completed to be $7.8 million ($1.3 million for each of six plants). With a required rate of return of 15%, the implied annual capital costs divided by average throughput for the Japanese market of 1,120 tonnes gives a capital cost of $1.04 per kilogram.

The risk premium is set at 10% of the premium net of packaging and capital costs. This figure is essentially arbitrary, but it is included to flag the potential importance of a risk premium in determining what otherwise appears to be a price premium.

Philippines

Calculations underlying the premium available to Philippines producers are set out in Table 9. Here we use the same basic methodology as set out for Thailand. According to the Department of Agriculture, Agribusiness and Marketing Assistance Service, the average domestic price for mangoes in the Philippines is $0.95 per kilogram. Using the same Japan price as in the Thailand calculations, this implies an initial premium of $4.90 per kilogram. Packaging and fruit-loss costs are estimated to be between $0.90 and $1.05 per kilogram.

Capital costs for the plants in the Philippines are not available due to commercial confidences, but the five plants operating in the Philippines have three times the capacity of their Thai counterparts, implying a capital cost of $19.5 million. With a rate of return of 15% and average throughput of just under 6,000 tonnes a year, this implies a capital cost of $0.49. The risk premium is treated in the same way as for Thailand.

Australia

Calculations underlying the premium for Australia are set out in Table 10. The average price as communicated by the Australian Mango Industry Association is $2.27 per

kilogram. Personal communication with the treatment plants in Australia showed the increase in packing costs to be between $1.06 and $1.29 per kilogram. Australia now has two VHT plants, neither of which existed before the start of the project. Incorporating capital costs of $1.6 million for two plants and average exports of 276 tonnes per year implies capital costs of $1.74 per kilogram (assuming a 15% rate of return).

Estimating the premium over time

The estimates above are for a premium applicable to 2004, the approximate period for which we can obtain relevant data. To estimate the premium for years *before* 2004, we assume that the same ad valorem premium applies in previous years, so that the premium moves in line with changes in overall prices. Tables 12–14 indicate the premiums calculated before 2004.

For the *future*, we assume that the Japanese premium will slowly decline as access to the Japanese market increases, particularly due to exports from India (the world's largest mango producer). Here we implicitly assume that either the availability of inspectors will increase over time, or that Japan will begin to accept assurances from the quarantine services of exporting countries. The rate at which the premium declines as imports increase depends on the elasticity of demand for mangoes in Japan. We have been unable to find any published estimates of this, so have estimated it indirectly by assuming that, at free trade, Japan will have the same per capita consumption as the United States. With this elasticity, we can estimate the decline in premium for a given increase in net imports. Assuming that imports from 2005 onwards grow at roughly double the rate before 2005, we estimate that the Japanese premium will be approximately one-third of its 2004 value by 2024. Tables 12–14 continue the pre-2004 series showing the premiums for after 2004.

Table 8. Thailand price premium ($ per kg) for exports of mangoes to Japan, 2004

Price to domestic and other export markets (free on board)	1.30
Price to Japan (free on board)	5.32–6.38
Initial premium (midpoint)	4.55
Less	
Packaging costs (materials and labour)	0.90
Capital costs	1.04
Risk premium	0.26
Equals	
Effective premium for 2004	2.35

Sources: Department of Agriculture, Thailand, pers. comm.; Queensland Department of Primary Industries and Fisheries

Table 9. Philippines price premium ($ per kg) for exports of mangoes to Japan, 2004

Price to domestic and other export markets (free on board)	0.95
Price to Japan (free on board)	5.32–6.38
Initial premium (midpoint)	4.90
Less	
Packaging costs (materials and labour)	0.98
Capital costs	0.49
Risk premium	0.34
Equals	
Effective premium for 2004	3.09

Source: Department of Agriculture, Agribusiness and Marketing Assistance Service. The Philippines

Table 10. Australian price premium ($ per kg) for sales of mangoes to Japan, 2004

Price to domestic and other export markets (free on board)	2.27
Price to Japan (free on board)	5.32–6.38
Initial premium (midpoint)	3.58
Less	
Packaging costs (materials and labour)	1.18
Capital costs	1.74
Risk premium	0.07
Equals	
Effective premium for 2004	0.59

Source: Australian Mango Industry Association

4 Estimating the benefits

Key assumptions

The procedure to estimate the benefits of the increased access to Japan at a premium price is based around calculating the shaded areas in Figure 5 using the simple model described in Chapter 2. Because all the base data contain the Japanese exports, our procedure is to calculate the effect of the removal of exports to Japan on domestic and export prices, then to use the two sets of prices and quantities (with Japan and without Japan) to calculate the surplus changes as a result of the exports to Japan. Results are expressed as the benefits (or costs in the case of domestic consumers) of moving from the hypothetical situation of no exports to Japan, to the observed situation with exports to Japan.

For the period 1994–2004, we use actual data, and for 2004–24 we project forward, broadly assuming growth rates similar to the historical period. Table 11 sets out the key estimating assumptions.

Base data and surplus calculations

Tables 12–14 present base price and quantity data for the situation with Japan. Tables 15–17 present estimated price and quantity data for the situation without Japan. Tables 18–20 present the change in economic surplus as a result of moving from without Japan to with Japan. They also show attribution to the ACIAR-funded research.

Total benefits

Table 21 summarises the total benefits attributed to the research and Table 22 the key project outcomes.

Total gross benefits are estimated to be $26.3 million, with $23.9 million accruing to the partner countries and $2.4 million to Australia. After accounting for the project costs of $5.5 million (in present value terms), this leaves total net benefits of $20.8 million, or $18.4 million if only benefits to partner countries are included. The overall benefit:cost ratio for the project is 4.8:1 (corresponding to an internal rate of return of 26.7%). If only benefits to partner countries are included, this becomes 4.3:1 (an internal rate of return of 25.2%).

Sensitivity analysis

As usual, the estimated project outcomes are sensitive to a number of key assumptions. For the analysis presented here, the most important assumptions are the estimates of the premium received from the Japanese market along with the estimates surrounding the attribution of gains in the Japanese market to the ACIAR-funded research. Other assumptions, including the estimates of demand and supply, have only very small impact on the overall results.

Figure 9 shows the sensitivity of the estimated total net benefits to changes in the base value of the underlying premium assumption (minus 50% to plus 20%). Results are most sensitive to the Philippines premium, followed by the Thai and then the Australian premium.

Figure 10 shows the sensitivity of estimated total net benefits to changes in the base values of the initial attribution of benefits to the ACIAR-funded research as well as the period over which these benefits are assumed to decline (according to the *s*-curve set out in Table 11). Results are most sensitive to the assumed rate of decline of Thai attribution, followed by the initial attribution to the Philippines. The importance of the assumed timing of decline in the Philippines is also important. Less sensitive are the assumption about Thailand initial attribution and the Australian attribution or timing of decline.

Table 23 shows the results of a systematic sensitivity analysis where all underlying input variables are varied by 30% (above and below) around their baseline values (using a uniform distribution). Results are presented as a 95% confidence interval. The results indicate that the upper and lower outcomes are all for the same broad order of magnitude.

In considering this, however, it is important to note that we have applied uniform distributions to each of the input variables. We suspect that, for the key premium variables, there is more downside than upside potential (that is, our base estimates are more likely to be an overestimate than an underestimate). While we have not quantified this, in an informal sense we consider this lower bound to be more likely than the upper bound.

Table 11. Key assumptions for the analysis

Variable	Australia	Thailand	Philippines	Rationale
Supply elasticity	0.5	0.5	0.5	Based on estimates reported in Jedele et al. (2003)
Domestic demand elasticity	−0.5	−0.5	−0.5	Based on estimates reported in Jedele et al. (2003) and Damian and Oropeza (2004)
Demand elasticity in other export markets	−10	−10	−10	Some slope in other export demand assumed due to unique characteristics of each country's exports
Japanese premium 1994	$0.63 per kg	$2.57 per kg	$2.51 per kg	See discussion in Chapter 3
Japanese premium 2024	$0.12 per kg	$0.70 per kg	$1.10 per kg	See discussion in Chapter 3
Attribution to ACIAR-funded research	80% initially, declining to 40% after 17 years[a]	40% initially, declining to 20% after 15 years[b]	5% initially, declining to 2.5% after 15 years[c]	See discussion in Chapter 2
Growth in exports to Japan 2005–24	1.6% per annum	9.7% per annum	0.1% per annum	Based on historical averages

[a] Attribution to ACIAR-funded research for Australian benefits follows a declining s-curve as follows: Attribution = 0.8−0.8/(1+ EXP(0.4*(17−*t*))) where EXP is the natural exponent and *t* is indexed from 1 to 31.

[b] Attribution to ACIAR-funded research for Thailand benefits follows a declining s-curve as follows: Attribution = 0.4−0.4/(1+ EXP(0.7*(15−*t*))) where EXP is the natural exponent and *t* is indexed from 1 to 31.

[c] Attribution to ACIAR-funded research for Philippine benefits follows a declining s-curve as follows: Attribution = 0.05−0.05/(1+ EXP(0.7*(15−*t*))) where EXP is the natural exponent and *t* is indexed from 1 to 31.

Sources: Based on sources listed

Table 12. Thailand mango quantities and prices *with* Japan

Year	**Domestic sales** (tonnes)	**Exports to other markets** (tonnes)	**Exports to Japan** (tonnes)	**Price for other markets** ($ per tonne)	**Price for sales to Japan** ($ per tonne)
1994	1,196,582	3,306	112	1,424	3,991
1995	1,196,344	3,545	111	1,411	3,955
1996	1,172,711	8,100	150	1,398	3,919
1997	1,189,889	8,353	185	1,385	3,884
1998	1,077,566	10,072	138	1,373	3,849
1999	1,451,300	10,292	181	1,360	3,814
2000	1,624,725	8,560	194	1,348	3,780
2001	1,689,173	10,367	460	1,336	3,745
2002	1,691,264	8,249	487	1,324	3,712
2003	1,691,902	7,096	1,002	1,312	3,678
2004	1,691,939	6,855	1,206	1,300	3,645
2005	1,782,317	7,522	1,323	1,288	3,672
2006	1,877,507	8,254	1,452	1,277	3,620
2007	1,977,765	9,057	1,593	1,265	3,564
2008	2,083,357	9,938	1,748	1,254	3,508
2009	2,194,567	10,905	1,919	1,242	3,451
2010	2,311,690	11,966	2,105	1,231	3,391
2011	2,435,040	13,130	2,310	1,220	3,328
2012	2,564,944	14,408	2,535	1,209	3,259
2013	2,701,749	15,810	2,781	1,198	3,185
2014	2,845,818	17,348	3,052	1,187	3,101
2015	2,997,534	19,036	3,349	1,176	3,005
2016	3,157,299	20,888	3,675	1,166	2,894
2017	3,325,537	22,920	4,032	1,155	2,764
2018	3,502,691	25,150	4,425	1,145	2,617
2019	3,689,231	27,597	4,855	1,135	2,455
2020	3,885,649	30,283	5,328	1,124	2,289
2021	4,092,461	33,229	5,846	1,114	2,130
2022	4,310,213	36,462	6,415	1,104	1,991
2023	4,539,475	40,010	7,039	1,094	1,876
2024	4,780,849	43,902	7,724	1,084	1,786

Source: see Chapter 3

Table 13. Philippines mango quantities and prices *with* Japan

Year	Domestic sales (tonnes)	Exports to other markets (tonnes)	Exports to Japan (tonnes)	Price for other markets ($ per tonne)	Price for sales to Japan ($ per tonne)
1994	479,040	23,596	5,464	772	3,286
1995	549,561	36,817	7,122	757	3,220
1996	857,449	34,814	5,437	803	3,418
1997	959,760	40,109	4,831	757	3,220
1998	892,581	46,388	6,191	850	3,615
1999	831,086	29,080	6,022	1,066	4,535
2000	808,301	34,409	5,618	811	3,450
2001	843,449	32,854	5,397	772	3,286
2002	919,838	30,594	5,601	819	3,483
2003	967,930	31,504	6,746	780	3,319
2004	931,868	28,364	7,303	950	4,042
2005	984,858	28,383	7,308	950	4,122
2006	1,040,752	28,402	7,313	950	4,096
2007	1,099,710	28,421	7,318	950	4,063
2008	1,161,900	28,439	7,322	950	4,031
2009	1,227,499	28,458	7,327	949	3,995
2010	1,296,693	28,477	7,332	949	3,955
2011	1,369,680	28,496	7,337	949	3,908
2012	1,446,668	28,515	7,342	949	3,854
2013	1,527,875	28,534	7,347	949	3,789
2014	1,613,532	28,553	7,352	949	3,709
2015	1,703,885	28,572	7,357	949	3,609
2016	1,799,189	28,591	7,361	949	3,486
2017	1,899,717	28,610	7,366	949	3,333
2018	2,005,754	28,629	7,371	948	3,149
2019	2,117,602	28,648	7,376	948	2,940
2020	2,235,580	28,667	7,381	948	2,720
2021	2,360,024	28,686	7,386	948	2,508
2022	2,491,287	28,705	7,391	948	2,321
2023	2,629,744	28,724	7,396	948	2,170
2024	2,775,789	28,744	7,401	948	2,055

Source: see Chapter 3

Table 14. Australia mango quantities and prices *with* Japan

Year	**Domestic sales** (tonnes)	**Exports to other markets** (tonnes)	**Exports to Japan** (tonnes)	**Price for other markets** ($ per tonne)	**Price for sales to Japan** ($ per tonne)
1994	21,475	2,623	115	2,404	3,038
1995	34,562	3,064	91	2,414	3,051
1996	24,691	2,952	75	2,654	3,355
1997	27,797	4,398	207	2,120	2,680
1998	32,772	3,602	193	2,179	2,754
1999	23,586	2,640	146	2,485	3,141
2000	34,646	3,124	301	2,073	2,620
2001	33,726	3,354	318	2,420	3,059
2002	36,906	3,737	330	2,356	2,979
2003	35,889	2,711	370	2,087	2,638
2004	34,405	2,289	475	2,270	2,869
2005	35,859	2,325	483	2,207	2,805
2006	37,372	2,362	490	2,145	2,722
2007	38,947	2,400	498	2,086	2,641
2008	40,587	2,438	506	2,028	2,562
2009	42,294	2,477	514	1,971	2,484
2010	44,071	2,516	522	1,917	2,409
2011	45,920	2,556	531	1,863	2,334
2012	47,845	2,597	539	1,811	2,261
2013	49,850	2,638	548	1,761	2,189
2014	51,936	2,680	556	1,712	2,116
2015	54,107	2,723	565	1,665	2,043
2016	56,367	2,766	574	1,618	1,969
2017	58,719	2,810	583	1,573	1,894
2018	61,168	2,855	593	1,529	1,817
2019	63,716	2,901	602	1,487	1,740
2020	66,369	2,947	612	1,446	1,665
2021	69,129	2,994	621	1,405	1,593
2022	72,003	3,041	631	1,366	1,527
2023	74,993	3,090	641	1,328	1,467
2024	78,105	3,139	651	1,291	1,414

Source: see Chapter 3

Table 15. Thailand mango quantities and prices *without* Japan

Year	Domestic sales (tonnes)	Exports to other markets (tonnes)	Exports to Japan (tonnes)	Price for other markets ($ per tonne)	Price for sales to Japan ($ per tonne)
1994	1,196,587	3,306	0	1,128	0
1995	1,196,349	3,545	0	1,411	0
1996	1,172,717	8,101	0	1,398	0
1997	1,189,897	8,354	0	1,385	0
1998	1,077,572	10,073	0	1,373	0
1999	1,451,307	10,293	0	1,360	0
2000	1,624,733	8,561	0	1,348	0
2001	1,689,191	10,369	0	1,336	0
2002	1,691,283	8,251	0	1,324	0
2003	1,691,942	7,099	0	1,312	0
2004	1,691,987	6,859	0	1,300	0
2005	1,782,370	7,526	0	1,288	0
2006	1,877,565	8,259	0	1,277	0
2007	1,977,827	9,063	0	1,265	0
2008	2,083,424	9,945	0	1,254	0
2009	2,194,639	10,912	0	1,242	0
2010	2,311,768	11,974	0	1,231	0
2011	2,435,123	13,139	0	1,220	0
2012	2,565,034	14,418	0	1,209	0
2013	2,701,845	15,821	0	1,198	0
2014	2,845,920	17,360	0	1,187	0
2015	2,997,641	19,049	0	1,176	0
2016	3,157,410	20,903	0	1,166	0
2017	3,325,651	22,936	0	1,155	0
2018	3,502,807	25,167	0	1,145	0
2019	3,689,347	27,615	0	1,134	0
2020	3,885,764	30,300	0	1,124	0
2021	4,092,576	33,247	0	1,114	0
2022	4,310,327	36,481	0	1,104	0
2023	4,539,591	40,030	0	1,094	0
2024	4,780,969	43,924	0	1 084	0

Source: Centre for International Economics' estimates

Table 16. Philippines mango quantities and prices *without* Japan

Year	Domestic sales (tonnes)	Exports to other markets (tonnes)	Exports to Japan (tonnes)	Price for other markets ($ per tonne)	Price for sales to Japan ($ per tonne)
1994	479,242	23,795	0	772	0
1995	549,793	37,128	0	756	0
1996	857,669	34,992	0	803	0
1997	959,946	40,265	0	757	0
1998	892,820	46,637	0	849	0
1999	831,392	29,294	0	1,065	0
2000	808,526	34,601	0	811	0
2001	843,664	33,022	0	772	0
2002	920,080	30,755	0	818	0
2003	968,214	31,689	0	780	0
2004	932,224	28,581	0	949	0
2005	985,230	28,598	0	949	0
2006	1,041,126	28,606	0	949	0
2007	1,100,084	28,614	0	949	0
2008	1,162,273	28,622	0	949	0
2009	1,227,871	28,631	0	949	0
2010	1,297,063	28,640	0	949	0
2011	1,370,047	28,649	0	949	0
2012	1,447,029	28,658	0	949	0
2013	1,528,230	28,667	0	949	0
2014	1,613,878	28,676	0	948	0
2015	1,704,219	28,684	0	948	0
2016	1,799,507	28,692	0	948	0
2017	1,900,015	28,700	0	948	0
2018	2,006,028	28,707	0	948	0
2019	2,117,849	28,715	0	948	0
2020	2,235,800	28,724	0	948	0
2021	2,360,219	28,734	0	948	0
2022	2,491,462	28,746	0	948	0
2023	2,629,902	28,759	0	948	0
2024	2,775,935	28,774	0	948	0

Source: Centre for International Economics' estimates

Table 17. Australia mango quantities and prices *without* Japan

Year	Domestic sales (tonnes)	Exports to other markets (tonnes)	Exports to Japan (tonnes)	Price for other markets ($ per tonne)	Price for sales to Japan ($ per tonne)
1994	21,475	2,625	0	2,403	0
1995	34,563	3,066	0	2,414	0
1996	24,691	2,954	0	2,654	0
1997	27,798	4,401	0	2,120	0
1998	32,773	3,605	0	2,179	0
1999	23,587	2,642	0	2,485	0
2000	34,649	3,128	0	2,073	0
2001	33,728	3,359	0	2,420	0
2002	36,908	3,742	0	2,356	0
2003	35,892	2,715	0	2,087	0
2004	34,409	2,295	0	2,269	0
2005	35,863	2,331	0	2,206	0
2006	37,376	2,368	0	2,145	0
2007	38,951	2,405	0	2,085	0
2008	40,591	2,444	0	2,027	0
2009	42,298	2,482	0	1,971	0
2010	44,075	2,522	0	1,916	0
2011	45,925	2,562	0	1,863	0
2012	47,850	2,602	0	1,811	0
2013	49,854	2,643	0	1,761	0
2014	51,940	2,685	0	1,712	0
2015	54,112	2,728	0	1,664	0
2016	56,372	2,771	0	1,618	0
2017	58,724	2,815	0	1,573	0
2018	61,172	2,859	0	1,529	0
2019	63,721	2,905	0	1,487	0
2020	66,373	2,951	0	1,445	0
2021	69,134	2,997	0	1,405	0
2022	72,007	3,045	0	1,366	0
2023	74,997	3,093	0	1,328	0
2024	78,110	3,142	0	1,291	0

Source: Centre for International Economics' estimates

Table 18. Thailand welfare and prices as a consequence of Japanese mango trade

Year	Domestic consumer surplus loss ($)	Domestic producer surplus gain ($)	Net economic surplus ($)	Attribution to ACIAR-funded project (proportion)	Net surplus attributed ($)
1994	13,354	300,953	287,600	0.40	115,034
1995	13,033	295,492	282,459	0.40	112,971
1996	17,281	395,594	378,313	0.40	151,291
1997	20,992	483,358	462,366	0.40	184,863
1998	15,389	357,212	341,823	0.40	136,604
1999	19,927	464,163	444,236	0.40	177,369
2000	21,078	492,880	471,802	0.40	188,025
2001	49,193	1,157,753	1,108,561	0.40	440,147
2002	51,370	1,214,318	1,162,948	0.39	458,307
2003	104,194	2,474,929	2,370,735	0.39	920,497
2004	123,565	2,951,004	2,827,439	0.38	1,066,143
2005	137,239	3,291,402	3,154,163	0.36	1,124,022
2006	147,092	3,549,930	3,402,838	0.32	1,091,881
2007	157,233	3,818,931	3,661,698	0.27	978,681
2008	168,129	4,109,272	3,941,143	0.20	788,229
2009	179,552	4,415,957	4,236,406	0.13	562,276
2010	191,438	4,737,615	4,546,177	0.08	359,723
2011	203,672	5,071,470	4,867,798	0.04	212,425
2012	216,060	5,412,568	5,196,509	0.02	119,154
2013	228,291	5,752,668	5,524,377	0.01	64,773
2014	239,902	6,078,828	5,838,926	0.01	34,506
2015	250,239	6,371,942	6,121,702	0.00	18,100
2016	258,477	6,606,104	6,347,628	0.00	9,354
2017	263,739	6,750,628	6,486,888	0.00	4,756
2018	265,411	6,777,339	6,511,929	0.00	2,373
2019	263,589	6,674,348	6,410,759	0.00	1,161
2020	259,447	6,461,166	6,201,719	0.00	558
2021	255,059	6,191,975	5,936,915	0.00	265
2022	252,634	5,937,438	5,684,804	0.00	126
2023	253,679	5,755,996	5,502,317	0.00	61
2024	258,742	5,677,238	5,418,496	0.00	30
Present value in 2004	**3,146,455**	**77,013,075**	**73,866,620**		**6,630,409**

Source: Centre for International Economics' estimates

Table 19. Philippines welfare and prices as a consequence of Japanese mango trade

Year	Domestic consumer surplus loss ($)	Domestic producer surplus gain ($)	Net economic surplus ($)	Attribution to ACIAR-funded project (proportion)	Net surplus attributed ($)
1994	312,865	13,997,047	13,684,182	0.05	684,171
1995	351,526	17,825,352	17,473,825	0.05	873,594
1996	352,935	14,542,698	14,189,763	0.05	709,329
1997	282,272	12,169,449	11,887,178	0.05	594,090
1998	406,516	17,496,615	17,090,099	0.05	853,726
1999	652,679	21,502,113	20,849,434	0.05	1,040,561
2000	365,139	15,165,128	14,799,988	0.05	737,273
2001	332,732	13,875,136	13,542,404	0.05	672,115
2002	396,499	15,294,875	14,898,376	0.05	733,913
2003	443,861	17,534,080	17,090,219	0.05	829,463
2004	675,901	23,201,246	22,525,345	0.05	1,061,705
2005	707,884	23,833,122	23,125,238	0.04	1,030,117
2006	709,822	23,668,922	22,959,100	0.04	920,871
2007	709,066	23,444,552	22,735,486	0.03	759,579
2008	708,184	23,227,211	22,519,027	0.03	562,976
2009	705,818	22,981,354	22,275,536	0.02	369,565
2010	701,677	22,699,400	21,997,723	0.01	217,575
2011	695,350	22,370,513	21,675,163	0.01	118,235
2012	686,258	21,979,296	21,293,038	0.00	61,030
2013	673,610	21,504,281	20,830,671	0.00	30,530
2014	656,372	20,916,618	20,260,246	0.00	14,966
2015	633,310	20,180,019	19,546,709	0.00	7,224
2016	603,184	19,254,113	18,650,928	0.00	3,436
2017	565,203	18,104,449	17,539,246	0.00	1,607
2018	519,758	16,721,727	16,201,968	0.00	738
2019	469,160	15,146,577	14,677,416	0.00	332
2020	417,679	13,483,390	13,065,712	0.00	147
2021	370,298	11,879,936	11,509,638	0.00	64
2022	330,736	10,472,076	10,141,341	0.00	28
2023	300,263	9,332,675	9,032,412	0.00	12
2024	278,059	8,462,978	8,184,920	0.00	6
Present value in 2004	13,353,105	479,320,361	465,967,256		6,089,624

Source: Centre for International Economics' estimates

Table 20. Australia welfare and prices as a consequence of Japanese mango trade

Year	Domestic consumer surplus loss ($)	Domestic producer surplus gain ($)	Net economic surplus ($)	Attribution to ACIAR-funded project (proportion)	Net surplus attributed ($)
1994	3,856	77,144	73,288	0.80	58,533
1995	3,632	61,889	58,256	0.80	46,490
1996	2,987	55,829	52,842	0.80	42,118
1997	4,877	121,159	116,281	0.80	92,515
1998	5,865	117,257	111,392	0.79	88,386
1999	5,419	101,561	96,142	0.79	75,981
2000	9,359	174,324	164,965	0.79	129,598
2001	12,038	215,636	203,597	0.78	158,546
2002	11,859	217,601	205,741	0.77	158,147
2003	12,625	216,566	203,941	0.75	153,800
2004	19,536	303,851	284,315	0.73	208,534
2005	19,343	307,400	288,057	0.70	202,976
2006	18,938	301,213	282,275	0.67	187,886
2007	18,527	294,428	275,901	0.61	169,630
2008	18,128	287,860	269,733	0.55	148,887
2009	17,731	281,092	263,361	0.48	126,137
2010	17,336	274,047	256,711	0.40	102,684
2011	16,940	266,616	249,677	0.32	80,159
2012	16,539	258,647	242,107	0.25	60,048
2013	16,132	249,927	233,795	0.19	43,294
2014	15,711	240,176	224,465	0.13	30,165
2015	15,271	229,049	213,777	0.10	20,386
2016	14,807	216,174	201,367	0.07	13,399
2017	14,314	201,261	186,947	0.05	8,573
2018	13,793	184,292	170,500	0.03	5,342
2019	13,255	165,761	152,506	0.02	3,245
2020	12,723	146,779	134,056	0.01	1,929
2021	12,221	128,839	116,617	0.01	1,132
2022	11,773	113,248	101,475	0.01	663
2023	11,385	100,639	89,254	0.00	392
2024	11,054	90,922	79,869	0.00	235
Present value in 2004	308,601	4,927,471	4,618,870		1,801,436

Source: Centre for International Economics' estimates

Table 21. Total benefits and costs ($) attributed to the research

Year	Thailand	Philippines	Total partner benefits	Australia	Total benefits	Research costs
1994	115,034	684,171	799,205	58,533	857,738	
1995	112,971	873,594	986,565	46,490	1,033,054	
1996	151,291	709,329	860,620	42,118	902,738	
1997	184,863	594,090	778,953	92,515	871,467	
1998	136,604	853,726	990,331	88,386	1,078,717	
1999	177,369	1,040,561	1,217,930	75,981	1,293,911	
2000	188,025	737,273	925,299	129,598	1,054,897	
2001	440,147	672,115	1,112,262	158,546	1,270,808	
2002	458,307	733,913	1,192,220	158,147	1,350,366	
2003	920,497	829,463	1,749,961	153,800	1,903,761	
2004	1,066,143	1,061,705	2,127,848	208,534	2,336,382	
2005	1,124,022	1,030,117	2,154,139	202,976	2,357,115	
2006	1,091,881	920,871	2,012,752	187,886	2,200,638	
2007	978,681	759,579	1,738,259	169,630	1,907,889	
2008	788,229	562,976	1,351,204	148,887	1,500,091	
2009	562,276	369,565	931,841	126,137	1,057,978	
2010	359,723	217,575	577,298	102,684	679,982	
2011	212,425	118,235	330,659	80,159	410,818	
2012	119,154	61,030	180,185	60,048	240,232	
2013	64,773	30,530	95,302	43,294	138,597	
2014	34,506	14,966	49,472	30,165	79,637	
2015	18,100	7,224	25,324	20,386	45,710	
2016	9,354	3,436	12,790	13,399	26,189	
2017	4,756	1,607	6,363	8,573	14,937	
2018	2,373	738	3,111	5,342	8,453	
2019	1,161	332	1,493	3,245	4,738	
2020	558	147	705	1,929	2,633	
2021	265	64	329	1,132	1,461	
2022	126	28	154	663	817	
2023	61	12	73	392	465	
2024	30	6	35	235	271	
Present value in 2004	9,110,567	14,791,136	23,901,703	2,443,059	26,344,763	5,503,861

Source: Centre for International Economics' estimates

Table 22. Summary project economic outcomes

	$m
Gross benefits (present value)	
Total	26.3
Australia	2.4
Partner countries	23.9
Total cost of research	5.5
Net benefits (present value)	
Total	20.8
Partner countries only	18.4
Benefit:cost ratio	
Total	4.8:1
Partner countries only	4.3:1
Internal rate of return (%)	
Total	26.7
Partner countries only	25.2

Source: Centre for International Economics' estimates

Table 23. Sensitivity analysis of project outcomes (95% confidence interval)

	Lower ($m)	**Upper** ($m)
Gross benefits (present value)		
Total	16.1	39.1
Australia	1.2	4.0
Partner countries	13.8	36.6
Total cost of research	5.5	5.5
Net benefits (present value)		
Total	10.6	33.6
Partner countries only	8.3	31.1
Benefit:cost ratio		
Total	2.9:1	7.1:1
Partner countries only	2.5:1	6.6:1
Internal rate of return (%)		
Total	19.5	33.4
Partner countries only	17.5	32.1

Source: Centre for International Economics' estimates

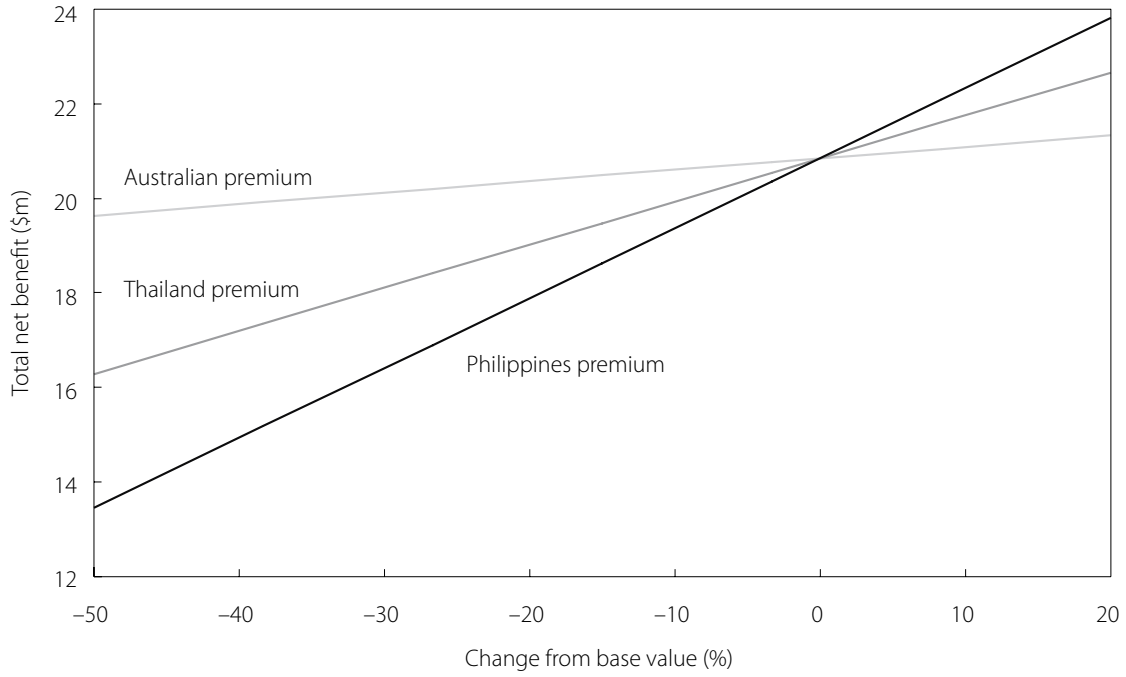


Figure 9. Sensitivity of net benefit to changes in the Japan price premium for mangoes.
Data source: Centre for International Economics' estimates

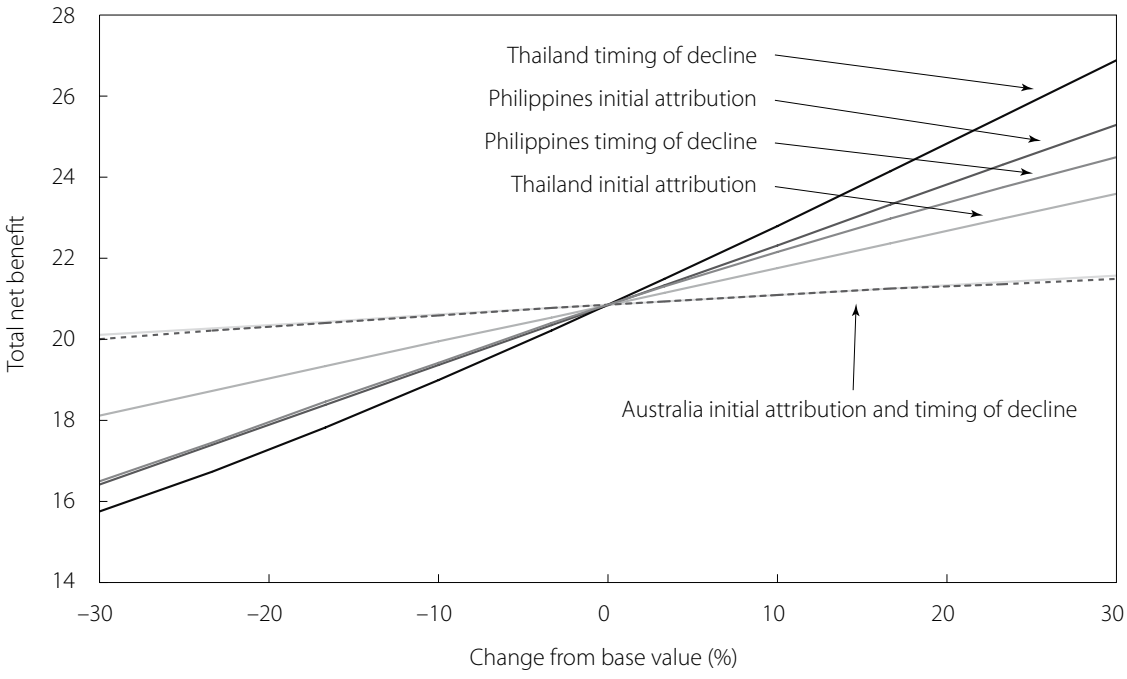


Figure 10. Sensitivity of net benefits to changes in attribution and timing of attribution.
Data source: Centre for International Economics' estimates

5 Conclusions

The economic impacts we have estimated for two projects: CS1/1990/012, 'Flowering behaviour and subsequent productivity in mango', and PHT/1990/051, 'Development of heat treatment systems for quarantine disinfestation in tropical fruit', are set out in Table 24.

While the heat-treatment project is estimated to have produced a respectable benefit:cost ratio of 4.8:1, there are some important caveats to this result. First, the results depend on two crucial assumptions: the estimated premium for exports to Japan; and the estimated attribution of the observed benefits of trade with Japan to the ACIAR-funded research.

Premiums for trade with Japan have been indirectly estimated since, due to commercial confidences, they are not directly available. There is a possibility that we have significantly overestimated these, as we have not been able to account for all factors determining the premium. However, the project will still generate net benefits as long as the premiums are no less than 20% of the values we have used here. While in terms of premium estimates alone (see below) we are confident that the project has generated net benefits, the difficulty in obtaining such a fundamental piece of information illustrates pitfalls in undertaking impact assessment of

Table 24. Summary of project economic outcomes

	Project PHT/1990/051 Heat treatment ($m)	**Project CS1/1990/012 Mango flowering** ($m)
Gross benefits (present value)		
Total	26.3	0.0
Australia	2.4	0.0
Partner countries	23.9	0.0
Total cost of research	5.5	5.3
Net benefits (present value)		
Total	20.8	–5.3
Partner countries only	18.4	–5.3
Benefit:cost ratio		
Total	4.8:1	0
Partner countries only	4.3:1	0
Internal rate of return (%)		
Total	26.7	n.a.
Partner countries only	25.2	n.a.

Source: Centre for International Economics' estimates

research that ultimately has a commercial objective in a highly competitive market.

The attribution of the significant benefits of trade with Japan to the ACIAR-funded project is fundamentally problematic. The research took place at a time of great interest in getting access to the Japanese market and many agencies (including Japanese funding agencies themselves, as well as commercial enterprises) were examining issues surrounding heat treatment for quarantine. In addition, significant further work has been undertaken since the ACIAR-funded project finished. We have taken these facts to imply two things: first, that complete attribution even of historical benefits is not appropriate and, second, that attribution must decline over time.

The project continues to generate net benefits as long as the attribution is not less than 21% of the value we have used here, or as long as the time that the benefits last is not reduced by more than one-third. If both of these are reduced, then a reduction of more than 50% would eliminate the net benefits of the project.

The combination of premium and attribution uncertainty, however, further constrains the possibilities for a net benefit: if these, in combination, are reduced by more than 60% of the base values, then the project will not generate net benefits.

While our broad sensitivity analysis (varying all of these factors independently) indicates a relatively narrow range of net benefits, we suspect that there is more downside risk than upside potential.

Difficulties in being able to quantify the impacts of the mango-flowering project were largely related to the fact that the research undertaken has remained at a basic R&D level and did not immediately translate to changed production practices. There remains, however, the possibility that this research will prove crucial in assisting the results of future research programs. Further, the research is likely to have had capacity-building benefits that we have not quantified here.

References

ACIAR 1990. Heat treatment systems for quarantine disinfestation in tropical fruit. Project PHT/1990/051 documentation. ACIAR: Canberra.

CAO (Market Access Ombudsman) 2007. Dispatching plant quarantine inspectors to control the vapor heat treatment of fresh fruits before being shipped to Japan. At: <http://www5.cao.go.jp/otodb/english/mondai/subject/199600101.html>. Accessed June 2007.

Corcoran R., Peterson P., Heslin L., Eelkema M. and Jev E. 2002. Study of the response to heat of Queensland fruit fly in mangoes allows additional varieties to be exported to Japan. Acta Horticulturae 575 673–679.

Damian M. and Oropeza J. 2004. An almost ideal demand system (AIDS) applied to eleven fruits in Mexico. Revista Fitotecina Mexicana 27(4), 367–375.

Gordon J. and Chadwick K. 2007. Impact assessment of capacity building and training: assessment framework and two case studies. ACIAR Impact Assessment Series Report No. 44.

Gordon J. and Davis J. 2007. ACIAR impact assessment: guidelines for practitioners. [May 2007 working draft of a manuscript to be published as a report in the ACIAR Impact Assessment Series.] ACIAR: Canberra.

Jedele S., Hau A. and von Oppen M. 2003. An analysis of the world market for mangos and its importance for developing countries. Paper presented at conference on international agricultural research for development, Gottingen, 8–10 October 2003.

Kitigawa H., Matsui K., Kawada K. and Agravante J.U. 1990. Japan as a market of tropical fruit. Acta Horticulturae 269, 41–46.

Kuo L.S. 1988. Quarantine treatment for fresh fruits to be exported to Japan. Chinese Journal of Entomology Special Publication 2, 133–139.

Lantican J.M. 1997. Market prospects for upland crops in the Philippines. The CGPRT Centre, Working Paper Series No. 22 (January).

Whiley A. 1997. Flowering behaviour and subsequent productivity in mango, ACIAR Project 9012. Department of Primary Industries, Queensland, Annual Report 1996–97.

IMPACT ASSESSMENT SERIES

No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Centre for International Economics (1998)	Control of Newcastle disease in village chickens	8334, 8717 and 93/222
2	George, P.S. (1998)	Increased efficiency of straw utilisation by cattle and buffalo	8203, 8601 and 8817
3	Centre for International Economics (1998)	Establishment of a protected area in Vanuatu	9020
4	Watson, A.S. (1998)	Raw wool production and marketing in China	8811
5	Collins, D.J. and Collins, B.A. (1998)	Fruit fly in Malaysia and Thailand 1985–1993	8343 and 8919
6	Ryan, J.G. (1998)	Pigeon pea improvement	8201 and 8567
7	Centre for International Economics (1998)	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	9130
8	McKenney, D.W. (1998)	Australian tree species selection in China	8457 and 8848
9	ACIL Consulting (1998)	Sulfur test KCL–40 and growth of the Australian canola industry	8328 and 8804
10	AACM International (1998)	Conservation tillage and controlled traffic	9209
11	Chudleigh, P. (1998)	Post-harvest R&D concerning tropical fruits	8356 and 8844
12	Waterhouse, D., Dillon, B. and Vincent, D. (1999)	Biological control of the banana skipper in Papua New Guinea	8802-C
13	Chudleigh, P. (1999)	Breeding and quality analysis of rapeseed	CS1/1984/069 and CS1/1988/039
14	McLeod, R., Isvilanonda, S. and Wattanutchariya, S. (1999)	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008 and PHT/1990/008
15	Chudleigh, P. (1999)	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod, R. (2001)	Control of footrot in small ruminants of Nepal	AS2/1991/017 and AS2/1996/021
17	Tisdell, C. and Wilson, C. (2001)	Breeding and feeding pigs in Australia and Vietnam AS2/1994/023	
18	Vincent, D. and Quirke, D. (2002)	Controlling *Phalaris minor* in the Indian rice–wheat belt	CS1/1996/013
19	Pearce, D. (2002)	Measuring the poverty impact of ACIAR projects—a broad framework	
20	Warner, R. and Bauer, M. (2002)	*Mama Lus Frut* scheme: an assessment of poverty reduction	ASEM/1999/084
21	McLeod, R. (2003)	Improved methods in diagnosis, epidemiology, and information management of foot-and-mouth disease in Southeast Asia	AS1/1983/067, AS1/1988/035, AS1/1992/004 and AS1/1994/038
22	Bauer, M., Pearce, D. and Vincent, D. (2003)	Saving a staple crop: impact of biological control of the banana skipper on poverty reduction in Papua New Guinea	CS2/1988/002-C
23	McLeod, R. (2003)	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011 and AS2/1993/001
24	Palis, F.G., Sumalde, Z.M. and Hossain, M. (2004)	Assessment of the rodent control projects in Vietnam funded by ACIAR and AUSAID: adoption and impact	AS1/1998/036

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
25	Brennan, J.P. and Quade, K.J. (2004)	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037 and CS1/1988/014
26	Mullen, J.D. (2004)	Impact assessment of ACIAR-funded projects on grain-market reform in China	ANRE1/1992/028 and ADP/1997/021
27	van Bueren, M. (2004)	Acacia hybrids in Vietnam	FST/1986/030
28	Harris, D. (2004)	Water and nitrogen management in wheat–maize production on the North China Plain	LWR1/1996/164
29	Lindner, R. (2004)	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081
30	van Bueren, M. (2004)	Eucalypt tree improvement in China	FST/1990/044, FST/1994/025, FST/1984/057, FST/1988/048, FST/1987/036, FST/1996/125 and FST/1997/077
31	Pearce, D. (2005)	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce, D. (2005)	Shelf-life extension of leafy vegetables—evaluating the impacts	PHT/1994/016
33	Vere, D. (2005)	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce, D. (2005)	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer, D.A. and Lindner, R. (2005)	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner, R. (2005)	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017 and FIS/1999/076
37	McLeod, R. (2005)	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115 and CS2/1996/225
38	ACIAR (2006)	Future directions for ACIAR's animal health research	
39	Pearce, D., Monck, M., Chadwick, K. and Corbishley, J. (2006)	Benefits to Australia from ACIAR-funded research	FST/1993/016, PHT/1990/051, CS1/1990/012, CS1/1994/968, AS2/1990/028, AS2/1994/017, AS2/1994/018 and AS2/1999/060
40	Corbishley, J. and Pearce, D. (2006)	Zero tillage for weed control in India: the contribution to poverty alleviation	CS1/1996/013
41	ACIAR (2006)	ACIAR and public funding of R&D, Submission to Productivity Commission study on public support for science and innovation	
42	Pearce, D. and Monck, M. (2006)	Benefits to Australia of selected CABI products	
43	Harris, D.N. (2006)	Water management in public irrigation schemes in Vietnam	LWR2/1994/004 and LWR1/1998/034
44	Gordon, J. and Chadwick, K. (2007)	Impact assessment of capacity building and training: assessment framework and two case studies	CS1/1982/001, CS1/1985/067, LWR2/1994/004 and LWR2/1998/034
45	Turnbull, J.W. (2007)	Development of sustainable forestry plantations in China: a review	
46	Monck M. and Pearce D. (2007)	Mite pests of honey bees in the Asia–Pacific region	AS2/1990/028, AS2/1994/017, AS2/1994/018 and AS2/1999/060

IMPACT ASSESSMENT SERIES <CONTINUED>

No.	Author(s) and year of publication	Title	ACIAR project numbers
47	Fisher, H. and Gordon, J. (2007)	Improved Australian tree species for Vietnam	FST/1993/118 and FST/1998/096
48	Longmore, C., Gordon, J., and Bantilan, M.C. (2007)	Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia	CS1/1994/968
49	Fisher, H. and Gordon, J. (2007)	Minimising impacts of fungal disease of eucalypts in South-East Asia	FST/1994/041
50	Monck, M. and Pearce, D. (2007)	Improved trade in mangoes from the Philippines, Thailand and Australia	PHT/1990/051 and CS1/1990/012

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

From: Monck, M. and Pearce, D. *Improved trade in mangoes from the Philippines, Thailand and Australia*. ACIAR Impact Assessment Series Report No. 50, July 2007

ACIAR Impact Assessment Series 50

Improved trade in mangoes from the Philippines, Thailand and Australia





ACIAR
Part of Australia's development assistance program

www.aciar.gov.au