ASSESSMENT OF RODENT CONTROL PROJECTS IN VIETNAM: ADOPTION AND IMPACT

ACIAR Project AS1/1998/036
AusAID CARD Project 2000/024
ACIAR/World Vision Project VN31-174945

Florencia G. Palis
Zenaida M. Sumalde
Mahabub Hossain

International Rice Research Institute
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▶▶▶▶ Communications regarding any aspects of this series should be directed to:
The Manager
Impact Assessment Unit
ACIAR
GPO Box 1571
Canberra ACT 2601
Australia
tel +612 62170500
email <aciar@aciar.gov.au>

Florencia G. Palis, Zenaida M. Sumalde, Mahabub Hossain. International Rice Research Institute.

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Foreword

Rodent control has been the focus of a number of ACIAR projects in Vietnam and other countries since the early 1990s.

Rodents adversely affect rural families in three main ways: they eat agricultural crops in the field; they eat, spoil and contaminate stored food; and they carry diseases of humans and their livestock. In the Asia–Pacific region, rodents are one of the most important constraints to agricultural production. Management of rodent pests in agricultural regions is a high priority for reducing poverty.

Research carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and a number of partner organisations and supported by ACIAR has been aimed at developing an ecologically based approach to rodent management. This concept promotes actions that facilitate sustainable agriculture with minimum impact on the environment.

This impact assessment was carried out to examine the level of adoption of research results by rice farmers, the general community and policy-makers in Vietnam and the sustainability of adoption. Its findings will be important as a basis for planning any future projects to facilitate the uptake of research on rodent control in Vietnam.

Peter Core
Director
Australian Centre for International Agricultural Research

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Collaborating organisations	CSIRO Sustainable Ecosystems, Canberra, Australia (CSE); National Institute of Plant Protection, Hanoi, Vietnam (NIPP)
Project leaders	Dr Grant Singleton (CSE); Professor Le Van Thuyet (Director, NIPP)
Principal researchers	Mr Peter Brown (CSE); Dr Nguyen Van Tuat and Dr Tran Quang Tan (NIPP)
Duration of project	1 January 1999 – 30 June 2003
Total ACIAR funding	A$291,504
Project objectives in Vietnam	To establish and monitor the effectiveness of an integrated rodent management program at the village level (IRM-V) To establish and maintain a 'rodent pest network' linked with the International Rice Research Institute's (IRRI's) integrated pest management (IPM) network To improve rodent field methods and management through training, simple field manuals and extension literature To extend the results of the village-level study to Plant Protection Department staff in five provinces of northern Vietnam
Location of project activities	Me Linh District, Vin Phuc Province

ACIAR–World Vision project CTE/2000/165 (Vietnam component only)	Facilitating farmer uptake of ACIAR project results: Component 4 — Rat control in rice-based farming systems (World Vision project VN31-174945)
Collaborating organisations	World Vision Australia (WVA); World Vision Vietnam (WV-VN); CSE, Australia; NIPP, Vietnam; Institute of Animal Sciences, Vietnam (IAS); provincial Plant Protection Departments, Vietnam (PPDs); CARE International
Project leaders	Graham Tardif (WVA); David Purnell (WV-VN)
Duration of project	1 January 2001 – 31 December 2003
Total ACIAR funding	A$83,066
Project objective	To utilise IRM-V technologies developed in ACIAR projects, including the community trap-barrier system, as a technical component of a larger WV-VN rural development project in south-central Vietnam
Location of project activities	Bac Binh, Tuy Phong and Ham Thuan Bac districts, Bin Thuan Province

AusAID Capacity-building for Agriculture and Rural Development (CARD) project 2000/024	Enhancing capacity in rodent management in the Mekong delta region using non-chemical methods
Collaborating organisations	CSE Australia; International Rice Research Institute, Los Baños, Philippines (IRRI); IAS, Vietnam; PPDs, Vietnam
Project leader	Dr Grant Singleton (CSE)
Duration of project	July 2000 – mid-October 2002
Total AusAID CARD funding	A$317,200
Project objective	To extend community-based rodent management approaches developed in ACIAR-funded projects through training of PPD extension staff
Location of project activities	Tien Giang and Soc Trang provinces

Summary

As a result of two previous projects funded by the Australian Centre for International Agricultural Research (ACIAR) on management of rodent pests in Southeast Asia (AS1/1994/020 and AS1/1996/079), a four-year project (AS1/1998/036) followed, entitled *Managing rodents in rice-based farming systems.* This project focused on delivering cost-effective, environmentally friendly, benign, rodent control technologies such as the trap–barrier system (TBS) and integrated rodent management at the village level (IRM-V). It had five components: (1) physical control using a trap–barrier system, now commonly called a community trap–barrier system (CTBS); (2) management at the village level; (3) forecasting and understanding the ecology of rodent populations; (4) biological control; and (5) rodent pest control networking and training. Two of these components (1 and 2) are covered in this assessment.

In addition to the research supported by ACIAR, the Australian Agency for International Aid (AusAID) funded a Capacity-building for Agriculture and Rural Development (CARD) project (2000/024) aimed at enhancing Vietnam's capacity in rodent management in the Mekong Delta region using non-chemical methods. This was a two-year project that ended in July 2002. ACIAR, in collaboration with World Vision, also funded a program that was designed to facilitate farmer uptake of ACIAR project results in Binh Thuan Province.

Despite the accomplishments of these projects, issues relating to current adoption and sustainability of adoption, and the change in farmers' net income as a result of adopting technology need to be assessed. The primary purpose of this adoption and impact assessment is to examine these issues.

Information used for this assessment was gathered from key informants among people involved in the ACIAR, AusAID CARD, and ACIAR–World Vision projects and from focus-group discussions among farmers representing the treatment and control areas in five provinces of Vietnam: Vinh Phuc (in the north), Binh Thuan (south-central), and Bac Lieu, Soc Trang, and Tien Giang (in the south).

Results of the assessment showed that IRM-V, which was introduced in the north, has been adopted. Farmers have also used the CTBS, but adoption has been relatively slow. This slow adoption can be attributed to the fact that farmers do not see the need to use this technology given the

currently low rat population. However, CTBS and IRM-V technologies have influenced government policy at both the national and provincial level. The results of the ACIAR project in the north became the basis for national government policy pronouncements about the use of IRM-V. These results also formed the basis of an information campaign about rat control, which was aired on television and radio. In addition, at the provincial level, a budget has been allocated for further CTBS demonstrations and implementation of IRM-V.

Farmers believe that the CTBS is effective, but they are constrained by the costs associated with the use of the technology. Based on the responses and observations from the study, conditions for CTBS adoption include (among other factors) the following: (1) monoculture farming; (2) good irrigation facilities; (3) presence of a strong, cooperative farmers' association, or an integrated pest management (IPM) club; (4) high rodent population; (5) partial subsidy for small farmers, cooperatives, farmers' association, or IPM club; (6) capacity building to strengthen existing cooperatives, farmers' association, or IPM club; and (7) large farm size for individual adoption.

As a new technology, the CTBS faces slow adoption. However, some positive indications imply continuous or sustained use of the technology, such as: (1) a policy pronouncement from the Prime Minister directing the use of integrated IRM; (2) existing infrastructure — for example, cooperatives for sustained implementation; (3) budgetary allocation from the government; (4) culture of community cooperation; (5) individual adoption by small farmers in areas with a high rodent population; (6) individual adoption by farmers with relatively bigger farms; and (7) strong support by provincial governments in the south (e.g. Bac Lieu) and north (e.g. Hai Phuong) that were not involved in the studies.

The quantitative benefits that farmers derive from the use of CTBSs and practice of IRM-V are increased yields resulting from reduced yield losses from rats, a lower rodent population in project areas, reduced use of toxic rodenticides due to the shift to ecologically based rodent-control methods, decreased use of plastic fences to protect the whole area, and decreased rodent control cost.

Results of the benefit–cost analysis (BCA) showed a positive impact on farmers' welfare in terms of financial benefits. In all five provinces, the net present values (NPVs) are positive and the benefit–cost ratios (BCRs) are greater than one. The sensitivity analysis without subsidy showed that, except for Soc Trang Province, the technology is still financially beneficial for the farmers in the provinces covered by the assessment.

Other impacts of the technology are improved environmental and health conditions and a more cohesive interaction among community members.

Among the recommendations forwarded, based on the results of the assessment, are the following: (1) extend the project that focuses on the delivery of these mature technologies (IRM-V and CTBS) to sustain the positive gains from the previous projects; (2) incorporate capacity-building, which would strengthen existing cooperatives, farmers' associations, or IPM clubs in the extension phase of the project; (3) study the modification of the CTBS to reduce the costs; (4) provide a credit facility for small farmers or cooperatives/farmers' associations; (5) include monitoring and assessment of the adoption process and its impact to determine the benefits of the project to society as a whole; and (6) characterise the nature of rodent problems in particular regions and develop management strategies tailored to the upland and rainfed lowland systems.

1 Introduction

Rice (*Oryza sativa* L.) is the staple food of more than half of the world's population (IRRI 1997) and Asian countries contribute nearly 90% of the total global production. Aside from being a staple food and common source of livelihood, rice also plays a major role in almost all Asian cultures.

Vietnam, an S-shaped country with 80 million people, is one of the major rice-producing countries in Asia. It stretches from the mountainous north and the Red River Delta to a narrow central belt snaking down to the fertile Mekong Delta in the south. It has a total agricultural land area of 9.4 million ha, 45% of which is for rice cultivation. Around 70% of the total labour force in the country work in agriculture. Total rice production in 2002 was 34,063,500 t, with an average yield of 4.5 t/ha (Cuc 2003).

Rice production in Vietnam, however, is threatened by rodent pests. Rodents generally cause chronic preharvest losses of 5–10% in rice and the problem is escalating in some regions (Singleton et al. 2003b). Rodents are considered one of the three most important problems facing the agricultural sector. With intensification of rice-growing from two to three rice crops a year, the rodent population and, consequently its damage to crops, has escalated. For example, the crop area with high rat damage increased from approximately 50,000 ha in 1993 to more than 310,000 ha in 1997 (Brown et al. 2004), much of which is rice.

The rice-field rat, *Rattus argentiventer*, is the most damaging rat species in Vietnam, followed by the lesser rice-field rat (*Rattus losea*). The rice-field rat is also an important rodent pest of rice crops in other parts of Southeast Asia, such as Malaysia and Indonesia.

The Australian Centre for International Agricultural Research (ACIAR) funded two projects in 1994 and 1996 (AS1/1994/020, *Management of rodent pests in Southeast Asia*, and AS1/1996/079, *Management of rodent pests in Vietnam*) to establish a better understanding of the population ecology and habitat use of rodent pests, and thereby develop environmentally friendly and sustainable rodent control technologies. The results of these projects provided a solid platform for the implementation of a four-year follow-up project (AS1/1998/036) entitled *Managing rodents in rice-based farming systems*, which had five components: (1) the community trap–barrier system (CTBS), (2) integrated rodent management at the village level (IRM-V), (3) forecasting and ecology of rodent populations, (4) biological control, and (5) rodent pest network and training.

In addition to the research supported by ACIAR, the Australian Agency for International Development (AusAID) funded a Capacity-building for Agriculture and Rural Development (CARD) project (2000/024) aimed at enhancing Vietnam's capacity in rodent management in the Mekong Delta region using non-chemical methods. Specifically, the intention of the CARD project was to develop the research and implementation capacity of Vietnamese agricultural researchers in the area of ecologically based (non-chemical) rodent management, and to help develop a regional plan for implementation and monitoring of effective rodent management. This two-year project was completed in July 2002.

During the life of the CARD project, another related project was carried out in Bac Binh District in Binh Thuan Province, funded under a joint ACIAR–World Vision Vietnam initiative. This rodent project, conducted in 2001–03, was the fourth of five components (CTE/2000/165) of the project *Facilitating farmer uptake of ACIAR project results: World Vision collaborative program*. This project (VN31-174945) aimed to introduce the CTBS and other methods of non-chemical control to this badly rodent-affected region to the east of the Mekong Delta.

Excellent progress was made in establishing village-level trap–barrier systems and other biological-control methods (review of AS1/1998/036 by Singleton et al. 2003a). Benefit–cost ratios (BCRs) were estimated (see, for example, Brown et al. 2004; Tuan 2003), and it was believed that the investment in rodent control had created political awareness at the national level as well as in government extension agencies and non-governmental organisations (NGOs). Rodent control measures have been extended to districts within the project target areas, with early results from activities in Vietnam looking promising. However, the pre- and post-project surveys conducted by social scientists at the International Rice Research Institute (IRRI) identified perceived constraints to adoption, particularly with regard to community actions and the problem of 'free-riders' (those who benefit from the system, but do not contribute to its cost or upkeep) (Morin et al. 2003; Palis et al. 2003).

Thus, this assessment was carried out to examine in more detail the (1) current adoption level of research results by rice farmers, the general community, and policy-makers in Vietnam, and (2) the sustainability of adoption. The key question that remained unanswered was this: *Will farmers continue to apply integrated village-level rodent-management strategies, including community trap–barrier systems (CTBSs), if these strategies are no longer subsidised by government or through donor funding?* Specifically, the assessment aimed to determine the changes in the economic welfare of farmers and the community resulting from the

adoption of CTBSs and/or other recommended rodent control measures, and describe the current and expected adoption levels and rates. As an *ex post* assessment, this assessment differs from an earlier assessment in the sense that the information used is based on the farmers' experiences in adopting integrated rodent management, including the use of the CTBS.

2 The rodent control projects and outcomes

The ACIAR project AS1/1998/036, entitled *Managing rodents in rice-based farming systems*, focused on delivering cost-effective, environmentally benign rodent-control technologies to rice farmers in Vietnam, Laos, and Indonesia. This assessment, however, concentrates only on Vietnam. It covers only the first two of the five components included in the project, namely, (1) CTBS and (2) IRM-V. In addition, AusAID funded a CARD project (2000/024) aimed at enhancing Vietnam's capacity in rodent management in the Mekong Delta region using non-chemical methods, and ACIAR, in collaboration with World Vision (WV), funded a program that was designed to facilitate farmer uptake of ACIAR project results in Binh Thuan Province. The general hypothesis of these projects is that rat control at the village level (where farmers implement cultural and/or physical rodent management practices) reduces the damage caused by rats and is cost-effective.

2.1 Technical background of the CTBS

The community trap–barrier system for rodent control in rice fields is an ecologically based rodent management strategy that aims to manage a low rat population in a sustainable and environmentally sound manner (Singleton et al. 1999). The system has the following components:

- a 'trap crop' (20 m × 20 m) planted about 20 days before the surrounding rice fields or area — the technology effectively controls an area of 10–15 ha
- a plastic barrier fence surrounding the trap crop, with small holes in the fence just above the irrigation water

- multiple-capture traps suspended on bamboo above the water level, placed adjacent to each hole — a mud mound provides access to the hole and hence to the trap.

Typically, no common property exists in a rice field, since rice is the sole property of the owner. But, when a TBS is established using shared resources, such as materials and labour, a common property is created, making it a CTBS. The shared benefits are reduced rodent damage to rice, and consumable rodents, and other consumable animals caught in the traps. The shared costs include: the cost of the fence and the labour to establish it, costs related to early establishment of the trap crop, and daily monitoring of the traps and the fence. Hence, the adoption of CTBS technology requires community participation.

2.2 Integrated rodent management at the village level

Integrated rodent management at the village level (IRM-V) involves both cultural and physical rodent management practices, such as the following:

- synchronising cropping
- using community trap–barrier systems
- collecting rodents in two-week campaigns at key times in the cropping cycle
- reducing the width of irrigation banks to less than 30 cm
- increasing general hygiene around villages and village gardens
- promoting synchronous fallow
- actions such as a rat bounty system at certain times during the crop, trapping and hunting, using rodenticides, and digging burrows if a high rodent population is forecast.

Scientists and extension officers developed these management practices by combining scientific knowledge on the biology and management of rodent pest species with the concept of ecologically based management defined by Singleton et al. (1999). Similar to the practice of using the CTBS alone, these other management practices require community action at the village level.

2.3 Scope and methodology of the projects

Farmer participatory research was conducted to refine and promote the CTBS and IRM-V. Knowledge of these technologies was transferred through training and action research through active partnerships and close cooperation among farmers, village agricultural officers (part of the people's committee for each village), research institutions such as the National Institute of Plant Protection (NIPP) and Institute of Agricultural Sciences (IAS), and Plant Protection Departments (PPDs) at the regional, provincial, and district levels.

Community trap–barrier system demonstrations were conducted in northern, south-central, and southern Vietnam. IRM-V, however, was conducted only in northern Vietnam. These demonstrations were conducted from 1998 to 2002 in northern and southern Vietnam and in 2001–02 in south-central Vietnam.

2.4 Project outcomes

Northern Vietnam

The trial was conducted in four sub-villages of Tien Phong village, Me Linh District, in Vinh Phuc Province. There are three main crop seasons during the year: two rice crops and a winter crop. More than 20 vegetable crops are grown throughout the year, such as tomato, squash, melons, onion, beans, and kohlrabi (cabbage turnip belonging to the crucifer family).

Farmers primarily grow rice, but nearly all of them practise mixed cropping — mostly rice and vegetables. This mixed-cropping practice is further strengthened with the recent policy of the Ministry of Agriculture instructing farmers to grow diversified crops (*Vietnam News*, 3 December 2003). Vegetables constitute the usual winter crop. The average farm size is 0.3 ha (8.4 sao; 1 sao = 360 m^2) — rice is normally grown on 0.19 ha (5.2 sao) and vegetables on 0.13 ha (3.6 sao).

Integrated rodent management at the village level (IRM-V) was carried out in two sub-villages or hamlets (treatment sites) where CTBS was established, wherein farmers were encouraged to practise field sanitation, synchronous land preparation, refuge reduction around villages, and postharvest clean-up. Two other hamlets represented control sites in which no rodent control advice was given. Ten CTBSs existed at the two treatment sites per season. Based on farmer estimates, use of the CTBS reduced yield loss in Vinh Phuc Province by 0.7 t/ha (Table 1).

Table 1. Estimated yield loss (t/ha) caused by rats, with and without a community trap–barrier system (CTBS), by province and season, Vietnam, 2002–03

	Yield loss due to rats[a]		Difference in yield loss
	With CTBS	Without CTBS	
Northern Vietnam			
Vinh Phuc			
Spring	0.6	0.8	0.2
Summer	0.7	1.2	0.5
Total/year	1.3	2.0	0.7
South-central Vietnam			
Binh Thuan			
1st season	0.7	1.3	0.6
2nd season	0.6	1.0	0.4
Total/year	1.3	2.3	1.0
Southern Vietnam			
Soc Trang			
Summer–autumn	1.2	2.5	1.3
Winter–spring	1.5	3.2	1.7
Spring–summer	1.4	2.9	1.5
Total/year	4.1	8.6	4.5
Tien Giang			
Winter–spring	0.4	1.1	0.7
Spring–summer	0.3	0.8	0.5
Summer–autumn	0.2	0.6	0.4
Total/year	0.9	2.5	1.6
Bac Lieu			
Summer–autumn	0.2	1.9	1.7
Autumn–winter	1.0	2.3	1.3
Total/year	1.2	4.2	3.0

[a] Based on estimates of farmer respondents during the focus-group discussions.

South-central Vietnam

In collaboration with World Vision Vietnam, ACIAR funded a two-year (January 2001 – December 2002) project on rodent control in rice crops (VN31-174945) in Bac Binh District, Binh Thuan Province, at an estimated cost of A$94,190 (Tuan 2003). The main project goal was to help farmers in the district to minimise rodent-inflicted damage in order to obtain improved rice crop yields, by providing information and training on the use of integrated pest management (IPM) techniques for rodent control, particularly the use of the CTBS. During the project, 21 CTBSs were established and operated by farmers over three seasons, depending on the

availability of rainfall and irrigation. This task was supported by other activities such as: (1) training lead farmers and government extension staff in CTBS operation; (2) establishing farmer groups to manage the CTBS sites, with savings and credit facilities through a cooperative to encourage the establishment of further CTBS sites; (3) developing extension pamphlets and training designs; and (4) establishing a network of contacts for transferring the CTBS technology to other parts of Vietnam.

Use of the CTBS proved to be effective in Binh Thuan Province. The difference in yield loss per ha between CTBS and non-CTBS farmers was estimated to be 1.0 t/ha (Table 1).

Southern Vietnam

The CTBS was introduced to rice farmers in the Mekong Delta in 1998 to facilitate farmer adaptation and, eventually, adoption on a large scale. AusAID funded a two-year CARD project (2000/024) from 2000 to 2002, aimed at enhancing Vietnam's capacity in rodent management in the Mekong Delta region, using non-chemical and ecologically based rodent control. The participatory experiment had two treatments — with CTBS and without CTBS — and was carried out in two provinces (Tien Giang and Soc Trang). Twenty-four CTBSs were established at the hamlet level: 12 CTBSs were established in two districts of Tien Giang (Cai Be and Cai Lay) and another 12 CTBSs in two districts of Soc Trang (My Tu and Long Phu). Control sites (without CTBS) were selected about 2 km away from each experimental hamlet. Similar to the other projects, the establishment of CTBSs at the treatment sites was financed by the project. This included materials for CTBSs, such as fences and rat traps, seeds for planting trap crops, labour for pumping water (because the trap crops had to be planted early), and labour for establishing CTBSs. Farmers' equity was in the form of ongoing labour, such as checking the rat traps daily and keeping records of the total numbers of rats caught. Farmers who had crops within the area protected by a CTBS (the 'halo of protection') were responsible for maintaining and managing their CTBS. Unlike in northern and south-central Vietnam, where labour for monitoring the traps was paid, farmers in the south employed different dynamics and institutional arrangements in CTBS management. For example, in Cai Be, trap monitoring was organised by the integrated pest management (IPM) club and rotated among club members. Since Vietnamese farmers eat the rats, the rule is 'check the trap and eat the rat'. In most cases, however, it was the trap-crop owner, and sometimes farmers from neighbouring farms, who monitored and maintained the CTBS. Similar to the other areas, the use of CTBSs was reported to decrease the yield losses due to rats in Soc Trang (4.5 t/ha) and Tien Giang Provinces (1.6 t/ha) (Table 1). As an

offshoot of the Tien Giang and Soc Trang experiences, the PPD of Bac Lieu adopted the use of CTBSs in several districts — 50 CTBSs were established for demonstration purposes, using a partial subsidy from the provincial government for materials, with encouraging results. In Bac Lieu the yield loss from rats was 3.0 t/ha less with the use of CTBS.

3 Methodology for impact assessment

Five provinces — Vinh Phuc in northern Vietnam, Binh Thuan in south-central Vietnam, and Soc Trang, Tien Giang, and Bac Lieu in southern Vietnam — were visited for the assessment. All the provinces except for Bac Lieu, which was an extension province, were pilot sites for the project. In each province, focus-group discussions (FGDs) among farmers in a treatment and control hamlet were conducted to elicit the information to be used in the assessment. Table 2 summarises the number of farmers in the FGD for each province. Information gathered included yield per ha, rice price, production cost, estimated yield loss caused by rats, and rodent management practices. The farmers in the treatment group were asked about their *experiences* with IRM-V and the use of the CTBS, while farmers in the control group were asked about their *perceptions* of IRM-V and the CTBS. Both treatment and control farmers were also asked whether they would erect their own CTBS even if no subsidy was provided.

Table 2. Distribution of farmers in the focus-group discussions, by province, Vietnam, 2003

Province	Treatment group	Control group
Vinh Phuc	10 (4 females and 6 males)	7 males
Binh Thuan (plus 11 farmer leaders)	16 (2 females and 14 males)	10 (4 females and 6 males)
Soc Trang	14 (2 females and 12 males)	8 (1 female and 9 males)
Tien Giang	9 males	6 males
Bac Lieu	19 (2 females and 17 males)	10 males
Hung Yen (World Vision site): 10 farmers, no treatment or control since the CTBS has yet to be introduced		

Information about government policy on rodent control and experience with IRM-V and CTBSs was also solicited from key persons at the national, provincial, and district levels of the PPD, IAS, and NIPP (a list of key informants is given in the acknowledgments).

The 'with CTBS' and 'without CTBS' framework was used when assessing farmers' benefits from using the CTBS. This was done by

obtaining the incremental benefits and incremental cost due to CTBS use. The benefits considered in the analysis consisted of the value of the differences between the CTBS and non-CTBS users in rice yield, the value of rats caught inside the CTBS, and cost savings from reduced use of rodenticides and plastic fencing.[1] Cost items consisted of the cost of rat control, including rodenticides and CTBSs. Since farm size varied considerably within and across provinces, costs and benefits were expressed on a per hectare basis for uniformity. The net present value (NPV) and the benefit–cost ratio (BCR) were the financial indicators used to assess the financial viability of subsidising the CTBS. A sensitivity analysis considering no subsidy for CTBS adoption was done to see whether the technology without subsidy would still be financially viable for the farmers. A discount rate of 10% was used for the estimation of NPV and BCR. To determine the sensitivity of the NPV to changes in the discount rate, two additional discount rates (5% and 15%) were used.

4 Impact, adoption, and indicators of sustainability

4.1 Status of and impact on adoption

Common rodent control practices

Farmers in Vietnam use a variety of methods to control rodents, such as chemicals, digging, hunting using dogs, trapping, electrocution, and, particularly in the north, plastic barrier fences around entire farms, at an average cost of A$5.88 (VND55,000[2]) per sao or 360 m^2 per season. Many farmers incorporate traps with their plastic barrier fences, or hunt and dig around their borders at night. The most popular traps used are kill-traps (metal and wood mechanical traps) and sticky-traps (sheets of sticky substance that physically traps rats). Sticky-traps are favoured for use in houses and kill-traps are preferred for use in the field. The rodenticides commonly used are warfarin (trade name Rat–K), zinc phosphide (an acute poison), and one from China, which is very toxic and whose active ingredient is not known. Families are primarily responsible for their own rodent and pest management actions. Rodenticides and traps are used individually, but digging and hunting are done in groups, indicating that collective action for rodent control is not new among Vietnamese farmers.

[1] Plastic fence was used only in northern Vietnam.

[2] A$1 = VND9356, which is the average conversion rate for 2002–03.

Northern Vietnam

Farmers at the treatment sites continue to practise the physical and cultural components of IRM-V, except for the CTBS. Likewise, control farmers adopted these IRM practices minus the CTBS, even during the project. As a result, it was reported that, from 1998 to 2002, a dramatic reduction occurred in the number of farmers using plastic fence to surround their whole crop area — from 100% to around 30% for both treatment and control groups. Likewise, the frequency of chemical rodenticide applications per cropping season has decreased from three applications to one application, which concurs with earlier findings (Brown et al. 2004).

However, some farmers at both sites have started to use a bio-rodenticide called 'bio-rat', which is Salmonella-based. Bio-rat is becoming popular with farmers because of strong marketing. Bio-rat is more expensive than the chemical rodenticides previously used by farmers. Data on the efficacy of bio-rat are sparse and there are major human health concerns[3] on its use (WHO 1967; Gratz 1994; Friedman 1996). The trend toward using bio-rat strengthens the need for continuing education and promotion of IRM-V and CTBS for controlling rats.

Farmers at both sites believe that controlling rats is most effective if done simultaneously at the community level. Thus, digging, hunting, and trapping are done at the same time in the village, though some farmers practise trapping individually. With IRM-V, rodent control is no longer the sole responsibility of individual families, but a concerted effort of all families in the village.

Farmers in northern Vietnam did not adopt the CTBS because they practise a mixed cropping system of rice–vegetables/ornamentals, which made it difficult for them to establish the CTBS in areas of 10–15 ha planted to rice. Because rice farms are scattered randomly, with vegetables and ornamentals in between, and because CTBS materials are expensive, farmers were not motivated to continue establishing CTBSs by themselves.

The organised community participation for rodent control in the villages in northern Vietnam is attributed to the presence of strong cooperatives, born of the traditional commune system, which is the key social capital in Vietnam and in which collective action is facilitated. For example, Tien Phong, a village in Me Linh District of Vinh Phuc Province, has seven

[3] Friedman et al. (1996) from the Centers for Disease Control in Atlanta, Georgia (USA), evaluated a sample and determined it to be *Salmonella enterica enterica* bioserotype *enteritides* (subgroup 1), which is a human pathogen.

hamlets with seven cooperatives. Each cooperative employs a security team in charge of village pest monitoring, including rodent control. Farmers contribute A$0.43 (VND4000[4]) every year to pay the security team, and for a rat bounty scheme, with PPD technicians doing pest forecasting. Each household has a quota of 20 rats per season. In excess of 20 rats, the cooperative pays the household A$0.02 (VND200[4]) per rat tail. The rat bounty campaign is part of the village mechanism for reducing the rat population and is the village response to IRM-V. It is usually done for a continuous period of five days and all household members participate. Village members do various community rodent control tasks, such as digging and trapping, simultaneously at specific crop stages for one or two days. The village leader announces the activity and representatives of each household participate.

Integrated rodent management at the village level spread in the north because of a policy issued by the Vietnamese Prime Minister in 1998 (Policy No. 09-1998/CT/TTG) directing all farmers to use IRM-V, organise groups for rodent control in each village, and limit the use of rodenticides. In addition, NIPP promoted IRM through television and radio from 1999 to 2000 and occasionally still does. Farmers were encouraged to control rats early every season (before breeding), particularly at the tillering stage or two weeks after planting, using various physical and cultural methods. Farmers were taught the importance of concerted community action. Both the policy proclamation and the media campaign emerged as a result of two ACIAR-funded projects, AS1/1994/020 (*Management of rodent pests in Southeast Asia*) and AS1/1996/079 (*Management of rodent pests in Vietnam*) in collaboration with NIPP, as the NIPP director and the PPD informed the Ministry of Agriculture (MOA) about the results of the ACIAR projects and recommended actions and policy directions. The MOA in turn endorsed the recommendation of the NIPP to the Prime Minister. Note that, before the ACIAR project, the national policy for rodent control was the use of chemicals.

Although the directive of the policy is at the national level, implementation depends on the capacity of the individual provinces. In Hai Phung Province, for example, A$23432–A$35148 (VND200–300 million[5]) was allocated for rat control from 1998 to 2000 (personal communication with Mr Cuong, director of the sub-PPD). The expenses covered were training, publications, and CTBS demonstrations. Sub-PPD staff trained farmers on IRM, including use of the CTBS, and instructed

[4] A$1 = VND9356, which is the average conversion rate for 2002–03.

[5] A$1 = VND8535, which is the average conversion rate for the three years ending 31 December 2000.

every village to undertake community action for rodent control. The village committee, in turn, organised the groups for rodent control, as instructed by the provincial people's committee in reference to Policy No. 09-1998/CT/TTG.

Based on the Bac Binh experience in Binh Thuan Province (south-central Vietnam), World Vision is implementing IRM-V elsewhere in Vietnam — IRM-V will be integrated in their 18 area development programs covering 12 provinces, mostly located in the north. At present, they are at the capacity-building stage.

South-central Vietnam

A rodent outbreak occurred in 2001 in Binh Thuan Province, as reported by farmers, World Vision staff, and sub-PPD staff. Big rodents (*Rattus bandicota*) migrated *en masse* from the mountains to rice fields searching for food, particularly in the Mayang village of Bac Binh. Mr Ngoc, sub-PPD director, attributed this mass rat migration to drought in the province causing a food shortage for rats in the mountains. Mean rat damage at that time was 40% (ranging from 30% to 100%). Rats caused very heavy damage to maize over a 4000 ha area in two districts (Tuan 2003). Thus, the ACIAR rodent project in Binh Thuan, which was facilitated in collaboration with World Vision, was well received by farmers and provincial governments through the sub-PPD. Farmer leaders (11 of them) in Bac Binh perceived that, because of the use of the CTBS, the rat population decreased in the CTBS areas but not in the non-CTBS areas. This perception emerged because of the low rat populations at treatment sites in spite of a dramatic reduction in the use of rodenticides (from 100% to 10%), compared with the high rodenticide use (90%) among control farmers. Synchronous planting and field sanitation were also practised in the CTBS areas although field sanitation was arbitrarily done in groups. An important point to note here is that the CTBS works not only in irrigated areas but also in rainfed and upland areas, as in the case of Bac Binh.

Farmers at the treatment and control sites in Bac Binh are now ready to adopt the CTBS technology even without a government subsidy. Farmers will seek financing through their cooperatives, which are as strong as those in the north. The cooperatives will be responsible for establishing, monitoring, and maintaining CTBSs. Payment will be collected from farmers after the harvest. This was supposed to be started by the farmers' cooperative in Phan Ri Thanh village but, because of the low rat population during the past two seasons, set-up of the CTBS was postponed as it would just entail additional cost. The 'free-rider' problem, which has been identified as a threat to CTBS adoption (Morin et al. 2003), will also

be resolved. With the strong culture of community spirit in Vietnam, the likelihood that farmers will establish CTBSs through their cooperatives is high.

On the part of the government, results of the pilot study in Bac Binh provided inputs to the MOA for demonstrating the effectiveness of the ACIAR/World Vision project. In 2002, the sub-PPD allocated funds for further demonstration of the CTBS in seven districts, but a low rat population at that time led to implementation being postponed. However, there are indications of a high rat population this year and the sub-PPD intends to set up CTBSs at several demonstration sites covering the seven districts, starting with the first crop of 2004.

As indicated by the World Vision leader in Bac Binh, other significant findings of the study were:

- more CTBS demonstration sites were set up, e.g. in Tuy Phong and Ham Thuan Bac, and resulted in reduced rodenticide use at those sites. Before the trials, all farmers used rodenticides, whereas only 10% of farmers still used them after the CTBS was introduced

- rat abundance decreased significantly in the three years after the CTBS was introduced into the communities in the Bac Binh, Tuy Phong, and Ham Thuan Bac districts

- capacity-building among the technical staff of Bac Binh was achieved through training by scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), IAS, and NIPP. These staff members, in turn, conducted training for farmers in their district and extension staff in other districts.

Southern Vietnam

Three provinces (Tien Giang, Soc Trang and Bac Lieu) were visited in southern Vietnam. Tien Giang, an original ACIAR pilot province, and Soc Trang were both CARD pilot provinces, and Bac Lieu became an extension province of the PPD based on the results in the other two provinces. Hence, it can be considered that the project in Bac Lieu represents a direct impact of the ACIAR–CARD-supported project on the government .

In southern Vietnam, farmers still use other methods such as electrocution and rodenticide, but to a lesser degree than before the trials. Incidents such as the recent deaths of 14 people by electrocution in Tien Giang (personal communication with Mr Chien, Director, PPD, Tien Gian Province)

highlight the dangers of the former method. Farmers believe that rodents can be controlled if farmers work together, and that rodenticides and other chemicals have harmful effects on human health and the environment. Thus, farmers in both the treatment (with CTBS demonstration) and control (non-CTBS demonstration) areas perceive the CTBS as an effective and safe method of controlling rats. Other gains from the CTBS projects include increased farmer awareness of the negative environmental effect of rodenticides, the importance of group action, and knowledge of an alternative but safe method of controlling rats.

In Tien Giang, 7 out of 13 (three of six in Cai Be, and four of seven in Cai Lay), or 54%, of the original CTBS farmers at the treatment sites are still using the CTBS. In general, there was a decrease in their use of rodenticide, which confirms earlier findings (Palis et al. 2003). Interestingly, farmers from the control group mentioned that they had also reduced their rodenticide use to some degree.

In Cai Be and Cai Lay, the CTBS has been adopted by individual farmers whose farms have a high rodent population and whose farm size is greater than 1 ha. The average farm size of a Vietnamese farmer in these two districts is 0.5 ha. Unlike in Cai Be, where the trap-crop owners shoulder all the expenses, farmer adopters in Cai Lay receive a 50% subsidy from the Plant Protection Stations (district level). It is important to note that surrounding farmers helped the farmer adopters establish CTBSs in both districts. It is the trap-crop owner, however, who does the daily monitoring of the trap crop, such as checking traps and maintaining the fence.

In Soc Trang, it was reported that none of the farmers continued using the CTBS after the project. Although farmers are convinced of its effectiveness, they are constrained by the high cost of CTBS materials and the labour requirement. It should be recalled that a CTBS that will cost VND1.5 million confers a ‘halo of protection’ of 15–20 ha. On a per hectare basis, it will cost the farmer only VND75,000–100,000. Farmers may not realise this per hectare cost because they compute the cost on a per CTBS basis — an indication that the concept of cost-sharing may not be well understood by the farmers. This issue could be minimised with the establishment of a cooperative or IPM club. In southern Vietnam, the sub-PPD has already formed 76 IPM clubs. In one treatment hamlet in My Tu District, the former IPM club was converted into a cooperative in 2001, and membership was extended to non-IPM members. This cooperative has linked up with the Canadian International Development Agency (CIDA) and received a grant of VND58 million. If the model of the Binh Thuan cooperative effort can be introduced in this case, the likelihood that CTBS use would be adopted and managed by the cooperative could increase.

As an offshoot of the Tien Giang and Soc Trang CTBS experience, around 50 CTBS demonstration sites were established in Bac Lieu Province from 2000 to 2002, as reported by the sub-PPD director, Mr Van Giep. These CTBSs were partially financed by the province at A$121 (VND1 million[6]) per CTBS — the cost of material inputs. So, over this time, the province of Bac Lieu spent A$6069 (VND50 million[6]) on the promotion of the CTBS to farmers as an alternative technology to the use of rodenticides. By 2003, the province had reduced its rodenticide allotment from A$1430–A$1907 (VND15–20 million[7]) to only A$477 (VND5 million[7]). The A$1430 (VND15 million[7]) difference was allotted to CTBS demonstrations. There are now 18 additional CTBS demonstrations in five villages of Vinh Loi District that were mainly financed by the PPD South. For all these CTBSs, the trap-crop owner is a volunteer and the PPD instructs 10 farmers to take turns in monitoring, without pay, throughout the cropping season.

Farmers from the treatment group in Bac Lieu expressed their satisfaction with the effectiveness of the CTBS in reducing yield loss from rats. They signified their intention to form farmer groups to continue to use the CTBS on their own without waiting for financial support from the government, with group members contributing equally to the establishment and management of CTBS. In 2003, the sub-PPD introduced other IRM practices to the farmers. Practices such as synchronised cropping should not be a problem in this province as irrigation facilities are available. The promotion of IRM in Bac Lieu in 2003 was in response to the national policy #09-1998/CT/TTG, as outlined above.

In contrast, farmers in the control group still use rodenticide because, during the 2002–03 cropping season, a chemical company, together with the PPD and Plant Protection Council of the village, encouraged the use of rodenticide and gave the chemicals free to farmers. As a result, they had no problem with mobilisation. In 2003, however, no free rodenticide was provided and the farmers had to buy the chemicals. Hence, they are now planning to use the CTBS, especially because the sub-PPD is allocating A$95 (VND1 million[7]) for the materials.

4.2 Other impacts

Environmental

Reduced use of plastic fencing. In the north, plastic fencing was frequently used to protect the entire rice farm. However, when the CTBS is

[6] A$1 = VND8238, which is the average conversion rate for the three years ending 31 December 2002.

[7] A$1 = VND10486, which is the average conversion rate for 2003.

used, fencing is needed around only a 20 × 20 m plot. Used plastic fencing is frequently left in the field or burned. If discarded in the field, the non-biodegradable plastic clogs irrigation channels and serves as habitat for rodents. If farmers dispose of the plastic by burning it, this emits dioxins, which are harmful to the ozone layer and human health. Since the projects, only 30% of farmers still use plastic fencing around their whole farm area — thus a significant reduction in the use of plastic has been achieved.

Reduced rodenticide use. The use of the CTBS and IRM-V has led to a reduction in the use of chemical rodenticides. This has a positive effect on the environment because residues from toxic chemicals that seep through the groundwater and have hazardous effects on humans, livestock, and other non-target organisms are minimised.

Health

Reduced health hazard. Reducing rodenticide use has a positive impact on health because exposure to toxic chemicals decreases. Although farmers reported no records of human death due to rodenticides, they mentioned that the chemicals might have resulted in skin problems and animal poisoning. In addition, reduced use of electrocution for rat control will reduce the risk of human death. Furthermore, a study under the CARD project relating to significant human health issues in the Mekong River Delta promoted awareness of rat-borne diseases among researchers, scientists, extension officers, professors and researchers in Vietnam universities, and farmers. A reduction in the rodent population that invades villages also helps reduce contamination of grain and water and thus benefits the health of humans and livestock.

Rodenticide-free edible rats. Field rats are normally part of the diet in Vietnam, particularly in the south. Rats caught through IRM-V and the CTBS are poison-free and thus edible.

Social–community cooperation

Activities for IRM-V and CTBS use require group or community participation. Thus, both can lead to more cohesive and healthier interactions between community members. The impact of community cooperation may be stronger in the south, which was influenced for decades by the culture of a capitalist society before the reunification of northern and southern Vietnam in 1976, i.e. there could be a more noticeable effect in the south than in the north because the north already has a strong community culture, whereas the south is less used to that way of thinking.

4.3 Conditions for adoption

Sustainability here refers to the continuous practice of IRM and use of the CTBS after the termination of the project and when needed,[8] either with government support or through farmers' own financing. However, like other technologies, there are catalytic conditions to be satisfied for sustained adoption or use. In the case of a new technology such as the CTBS, the rate of adoption may be slow, but indicators for sustainability may be present, such that the role of government and donor funding is to strengthen the conditions to hasten and sustain adoption.

Identified constraints to CTBS adoption include:

- high material cost of set-up — farmers tend to compute the cost on a per CTBS basis, rather than the relatively low per hectare basis
- difficulties in ensuring that all farmers in the area protected by a CTBS contribute financially to the cost of establishing and maintaining the system — in other words, there may be 'free-riders'
- high labour requirement for establishing, maintaining, and monitoring the system
- high transaction costs for establishing and running the system since it requires group action
- problems in establishing a small area for the trap crop several weeks before the main crop is planted, especially if there is no synchrony of planting among the farmers and the irrigation system cannot provide enough water to all the community at the same time
- difficulties can occur in harvesting/threshing rice from the trap crop, especially in bringing the thresher into the field with many standing rice crops around
- pest occurrence can result in low yields in the trap crop
- farmers have limited funds to cover the additional cost of the CTBS.

Responses of key people involved in IRM-V and CTBSs and feedback from farmers indicate that the adoption of both would be higher if the following conditions and mechanisms existed.

[8] There are times when farmers may not be motivated to use the CTBS — for example, when they perceive the rat population to be low.

Factors for enhanced CTBS adoption

- **Monoculture farming** (growing only rice). Because the CTBS is designed to cover 15 ha, it is difficult to establish if farmers are planting a variety of crops in the target area.

- **Good irrigation facilities**. One of the features of an effective CTBS is that all rice is planted within a two-week period. Synchronised planting requires uniform water availability in the area so that farmers can plant simultaneously within the desired period.

- **Presence of a strong cooperative, farmers' association or IPM club**. This is very important for both cost-sharing and activities requiring group or community effort, and would reduce the likelihood of a 'free-rider' problem.

- **High rodent population**. Although the main objective of CTBS use is to reduce the rat population, the returns to using the technology are likely to be higher when the rat population is high.

- **Partial subsidy for small farmers**. When the CTBS was first introduced to farmers in 1999, all associated costs (including labour for establishment and maintenance of the system, including the trap crop) were covered by the ACIAR project. During the focus-group discussions, farmers said that if the rat population were high, they would use the CTBS, but that they would need financial support for the cost of materials. Financial support is important, especially if there is no strong community group in the area. Where there is a strong cooperative, farmers' association or IPM club, the group may advance the expenses but they have to be paid back by the farmers after they harvest their rice crop.

- **Capacity-building to strengthen the existing cooperative, farmers' association, or IPM club**. Capacity-building will enhance implementation of IRM-V and increase the use of the CTBS, and is needed to strengthen group-sharing and community-effort activities. ACIAR, World Vision and other NGOs can all assist in strengthening the institutional capability of the country.

- **Large farm size for individual adoption**. Because of the costs involved, small farmers on an individual basis in Vietnam cannot afford to adopt the CTBS. However, some farmers with big landholdings currently use a modified (cheaper) version of the CTBS.

Conditions for enhancing IRM-V

- Strict enforcement of the national policy on IRM is needed at the provincial level. This calls for a continuous budget allocation for IRM-V activities, such as the institutional education campaign, promotion though mass media, and technology demonstrations.
- IRM-V needs a strong farmers' cooperative/association — the key social capital for effective implementation of technologies that require community action.
- Capacity-building is needed to teach farmers how to act collectively; impressing upon them the importance of group effort in rodent control. In addition, there is a need for continued education among PPD staff, extension workers, and village/cooperative leaders.
- A strong village/farmer leader (e.g. agricultural officer) is needed to spearhead the community activities for rodent control.

4.4 Indicators of sustainability

Results of the study show that, despite the relatively slow adoption of the CTBS in the pilot areas, some positive indicators imply sustainable or continuous use of the technology.

National government policy

At the national level, the strongest indicator of sustained use of CTBS and IRM-V is the Prime Minister's policy pronouncement, Policy No. 09-1998/CT/TTG. This policy directs all farmers to adopt IRM and establish farmers' groups to control rodents in each village. It encourages the use of physical or cultural methods of rat control. Concomitant with the policy is the limit on rodenticide use (the previous national policy directed farmers to use rodenticide for rodent control).

Government budget allocation at the provincial level

In response to the current policy on rodent control, several provinces have allocated funds for further CTBS demonstration sites. In Binh Thuan, for example, money has been allocated by the provincial-level PPD for CTBS demonstrations in seven districts. The PPD head of Hai Phuong Province spent VND200–300 million from 1998 to 2000 for CTBS demonstrations, training, and information and education campaigns among farmers about the importance of CTBS and IRM-V. In Bac Lieu, the province financed 50 CTBS demonstrations in several districts in 2000–02. In 2003,

VND30 million was allocated for IRM-V and CTBSs. Although still in the demonstration phase, this could be an indication of sustainability since the government itself has realised the effectiveness of the CTBS in controlling the rat population. As coverage increases, more farmers will derive benefits from the technology.

Non-government participation

The involvement of World Vision could contribute to the sustainability of CTBS and IRM-V. The positive results of the Bac Binh ACIAR–World Vision collaborative work on the CTBS resulted in the incorporation of IRM in World Vision's 18 area development programs (ADPs) covering 12 provinces in Vietnam. Its implementation has started in the north, where similar results are expected to those of Bac Binh, given the similar institutional set-up. Also, the capacity-building component of the World Vision ADPs should assist farmers to strengthen cooperatives at these sites. The participation of other NGOs should be encouraged as well.

Political culture and extension structures

One of the unique experiences of Vietnam is its being a socialist country under communist party rule. Under this system, adherence to government policy is easy to achieve. There are also strong, coordinated linkages between local political and extension institutions. Each administrative level has a People's Council and a People's Committee. The People's Councils represent the local authority of the state and are the top supervisory bodies at each level. They do not govern directly but instead elect and oversee People's Committees. The People's Committees are the executive bodies that carry out local administrative duties.

Every People's Committee has an agricultural officer who is normally the head of farmers' cooperatives. Likewise, the PPD, which is responsible for extending crop-protection technologies, has strong linkage with the People's Committees at the provincial, district, and village levels. Since the PPD is responsible for recommending or endorsing policies about crop protection to the central authority, technology dissemination is efficient.

Thus, infrastructure for the sustained implementation of the CTBS and IRM-V is already in place in Vietnam. The cooperative now exists to provide technical advice to the farmers, to help them increase their production and household income (through loans etc.), and to act as a bridge between the government and farmers. What is lacking are the resources and technical knowledge of implementers and farmers. The continuous involvement of government research and extension agencies,

such as the PPD (the government agency responsible for crop protection technologies), NIPP, and IAS (government agencies responsible for technical research issues), NGOs (such as World Vision), and entry of other new NGOs would facilitate capacity-building activities.

Culture of community cooperation

Coordinated community action is the norm rather than a novel concept in Vietnam. The Chinese influence of Confucianism, which is viewed as both a philosophy of life and as a religion, emphasised the importance of loyalty, respect for authority, and peacefulness (Quang 2003). Respect for social hierarchies is therefore basic to Vietnamese families and society. By far the most important of these values are those associated with family and community, where individual interest is subordinate, if not irrelevant, to the welfare of the whole group (Muoi 2002). Their experience in collective farming in the past has provided a strong foundation for effective collective action. Although this is more profound in the north, the concept is gradually evolving in the south as a result of unification. Hence, lower-level authorities and the general community will adhere to a directive coming from higher authorities. For rodent technology, the policy for IRM, which requires community action, can be implemented easily.

There have been positive impacts in West Java and spillover adoption of the projects discussed here in other countries — for examples, see Singleton et al. (2004) and Yadao (2003).

5 Financial benefit–cost analysis

5.1 Framework for the analysis

The analysis was carried out based on a 'with' and 'without' CTBS framework and focused on whether or not the CTBS was subsidised. Five provinces — Binh Thuan in south-central Vietnam, Vinh Phuc in northern Vietnam, and Bac Lieu, Soc Trang and Tien Giang in southern Vietnam — were covered in the assessment framework.

Because of variations in farm sizes across provinces, benefits and costs per year were expressed on a per hectare basis. Yield of rice, prices, and costs were assumed to be constant throughout the 10-year period of the projected analysis starting in 2002–03; hence, benefits and costs were assumed to be constant as well. Benefits and costs were discounted using a 10% discount rate. The indicators used in the analysis included net present

value (NPV) and benefit–cost ratio (BCR). A positive NPV and a BCR greater than one indicate that the project is beneficial from the farmers' point of view. Sensitivity of the NPV to changes in the discount rate was also tested using 5% and 15% discount rates.

A sensitivity analysis in which there is no subsidy for the CTBS was carried out to determine the financial viability of the technology if the full cost is borne by the farmers.

5.2 Estimation of costs

Costs involved in rice production included the costs of inputs such as seeds, rodenticides, fertiliser, pesticides etc., and, in the case of those using the CTBS, the cost of its establishment. The costs for the CTBS consisted of: the cost of materials, such as plastic, bamboo poles, and traps; the labour cost for establishment, monitoring, and maintenance; and the loss due to trap crops. Summaries of the total cost of rice production incurred by the farmer 'with CTBS' and 'without CTBS' and for the 'with subsidy' and 'without subsidy' scenarios for each province are shown in Table 3. It should be noted that the costs vary by province, depending on the farmers' reported production costs and the cost of the CTBS. Obviously, costs incurred by the farmer were lower if part or all of the cost of the CTBS was subsidised. In general, expenses for fertiliser and irrigation contributed a great bulk of the total production expenses (Table 4). Details of the production costs with and without CTBS and with and without subsidy are shown in Tables A1a–A1e.

With subsidy. As in other countries (Indonesia, Malaysia, Laos), the CTBS technology was introduced as a pilot project with a subsidy from ACIAR. As an offshoot of the ACIAR-funded projects, the Government of Vietnam, through the PPD, adopted the technology and set up CTBSs in Bac Lieu during 2000 to 2003. The subsidy considered in this report refers to the actual monetary costs provided to the farmers for CTBS establishment, whether from ACIAR or from the PPD. The amount of the subsidy varied depending on the source of funds and the CTBS components being subsidised. Thus, on a per hectare basis, if CTBS establishment was subsidised, the cost borne by the farmers ranged from 0.1% to 1.1% of the total production cost per year (Table 4). Most of the components in CTBS establishment were covered by the ACIAR-funded projects; hence, the maximum amount is given. Normally, the contribution by the farmers comes in the form of labour for maintenance and monitoring of the CTBS. With government funding, as in the case of Bac Lieu Province, labour for monitoring and maintenance and the loss in yield in the trap crop are generally borne by the farmer.

Without subsidy. Cost without subsidy refers to the situation wherein the farmer has to establish the CTBS without any support from the government. In this case, the cost has to be shouldered by all the farmers covered by the 'halo of protection' area, which is usually 15 ha. In this case, the cost to be absorbed by the farmers would be around 0.7–3.5% of the total production cost (Table 4).

Table 3. Cost of rice production ('000 VND/ha and A$/ha)[a] according to community trap–barrier system use ('with CTBS' and 'without CTBS'), by province, Vietnam, 2002–03

Province	With CTBS		Without CTBS
	With subsidy	Without subsidy	
Northern Vietnam			
Vinh Phuc			
Spring	8521	8597	8417
Summer	8590	8666	8417
Total/year (VND)	17,111	17,263	16,834
Total/year (A$)	1829	1845	1799
South-central Vietnam			
Binh Thuan			
1st season	5044	5104	4276
2nd season	5044	5044	5376
Total/year (VND)	10,088	10,148	9652
Total/year (A$)	1078	1085	1032
Southern Vietnam			
Soc Trang			
Summer–autumn	3886	3978	3846
Winter–spring	3886	3986	4000
Spring–summer	3505	3598	3158
Total/year (VND)	11,277	11,562	11,004
Total/year (A$)	1205	1236	1176
Tien Giang			
Winter–spring	5000	5000	4500
Spring–summer	4700	4800	4300
Summer–autumn	4000	4187	4000
Total/year (VND)	13,700	13,987	12,800
Total/year (A$)	1464	1495	1368
Bac Lieu			
Summer–autumn	5023	5075	5000
Autumn–winter	5500	5555	5300
Total/year (VND)	10,523	10,630	10,300
Total/year (A$)	1125	1136	1101

[a] Details of production cost are shown in Appendix Tables A1a–A1e.
Note: For Vinh Phuc, the cost savings due to non-use of plastic fence are considered benefits.

Table 4. Percentage distribution of cost of production according to community trap–barrier system use ('with CTBS' and 'without CTBS'), by province and item, Vietnam, 2002–03

	Vinh Phuc		Binh Thuan		Soc Trang		Tien Giang		Bac Lieu	
Item	With TBS	Without CTBS	With TBS	Without CTBS	With TBS	Without CTBS	With TBS	Without CTBS	With TBS	Without CTBS
Land preparation	9.7	9.9	16.3	17.2	12.1	12.0	12.2	12.0	11.9	12.0
Seed	1.8	1.8	13.3	13.9	2.4	2.4	2.4	2.4	2.4	2.4
Sowing	0.0	0.0	4.6	4.2	0.0	0.0	0.0	0.0	0.0	0.0
Pesticide	6.5	6.6	13.4	14.5	8.2	8.0	9.1	9.1	9.0	9.0
Fertiliser	10.7	10.1	7.4	7.3	27.6	23.9	27.1	27.6	27.8	25.6
Manure	9.4	10.1								
Rodenticide	0.6	1.0	16.1	17.6	0.3	4.3	0.1	0.3	0.1	2.5
Replanting/transplanting	4.7	5.0	8.3	8.3	5.9	6.0	6.0	6.0	6.0	6.0
Weeding	0.0	0.0	3.7	3.1	0.0	0.0	0.0	0.0	0.0	0.0
Harvesting	7.0	5.9	3.7	3.1	7.9	8.0	8.0	8.0	8.0	8.0
Threshing	2.9	3.3	3.7	3.1	3.9	4.0	4.0	4.0	4.0	4.0
Irrigation	8.8	6.6			17.8	18.0	18.0	18.0	23.2	19.6
Hauling			4.1	3.6						
Drying			4.4	4.1						
Plastic fence	26.0	20.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Service[a]	11.8	18.8			12.9	13.4	12.5	12.6	7.4	10.9
Subtotal	99.9	100.0	99.0	100.0	99.0	100.0	99.4	100.0	99.8	100.0
For CTBS										
With subsidy	0.1		1.0		1.0		0.6		0.2	
Total with subsidy	100.0		100.0		100.0		100.0		100.0	
Without subsidy	1.0		1.5		3.5		2.9		0.7	

[a] Except for Binh Thuan, with specific entries for hauling and drying, service includes the combined expenses for hauling and drying for the other provinces.

To determine the incremental cost due to rat control, only the costs associated with rodenticide use and CTBS establishment were considered. The costs associated with establishing the CTBS have two components:

- costs borne by the farmers — these consist mostly of the value of labour for CTBS establishment, monitoring and maintenance of CTBS, and loss due to trap crops
- costs subsidised by either the donor agency or the government — these consist mainly of the materials used for the CTBS. Note, however, that, in some cases, labour for CTBS establishment, monitoring, and maintenance is provided by the donor agency as well.

The incremental cost due to rat control was determined by obtaining the difference between the cost of rodenticide use for the CTBS users and non-CTBS users and for CTBS establishment. This was done for both the 'with subsidy' and 'without subsidy' situations.

5.3 Estimation of benefits

The benefits from rat control considered for the financial analysis consist of the following:

- incremental benefits from rice harvested — these are the value of the difference in yield between the CTBS users and non-CTBS users
- value of rats caught inside the CTBS —rats caught inside the CTBS are free from harmful chemicals and are safe for consumption
- cost savings from the reduction in rodenticide use — this item was obtained by determining the difference in cost of rodenticide used between the CTBS users and non-CTBS users
- cost savings from avoided use of plastic fence.

Results showed that the difference in yield due to CTBS use can be as high as 2 t/ha/year but can also be negative (Table 5). The latter case occurred in Bac Lieu Province, where the yield of farmers who used CTBS was lower by 0.2 t/ha than that of the non-CTBS users. The relatively higher yield of those without CTBS may be attributed to the high rodenticide and fertiliser application as well as high expenses for irrigation incurred by the non-CTBS farmers (Table A1e). However, as can be seen later, the incremental benefits, because of the value of rats and cost savings or

avoided cost from rodenticides, are still positive. Farmers from both the CTBS and non-CTBS sites in Soc Trang Province reported having the same yield, after deducting the estimated losses due to rats. This may be because of the technical assistance provided by the IPM clubs to farmers in the area, of which even the non-CTBS users are members. The farmers in Binh Thuan reported the highest incremental yield. This may be because the farmers who adopted the technology in this province are members of a strong cooperative that supplied farmers with inputs as well as marketing assistance and technical support.

Table 5. Yield per hectare (t/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), by province and season, Vietnam, 2002–03

Province	Actual yield[a]		Incremental yield[b]
	With CTBS	Without CTBS	
Northern Vietnam			
Vinh Phuc			
Spring	6.4	5.2	1.2
Summer	4.6	4.7	(0.1)
Total/year	11.0	9.9	1.1
South-central Vietnam			
Binh Thuan			
1st season	6.0	5.0	1.0
2nd season	5.0	4.0	1.0
Total/year	11.0	9.0	2.0
Southern Vietnam			
Soc Trang			
Summer–autumn	4.6	4.6	0.0
Winter–spring	6.0	6.0	0.0
Spring–summer	5.4	5.4	0.0
Total/year	16.0	16.0	0.0
Tien Giang			
Winter–spring	6.7	6.0	0.7
Spring–summer	4.8	4.3	0.5
Summer–autumn	3.8	3.4	0.4
Total/year	15.3	13.7	1.6
Bac Lieu			
Summer–autumn	4.5	4.5	0.0
Autumn–winter	4.0	4.2	(0.2)
Total/year	8.5	8.7	(0.2)

[a] Actual yield refers to the yield reported by the farmers net of estimated yield losses due to rats.
[b] The difference between the yield 'with CTBS' and 'without CTBS'.

5.4 Results of the financial BCA

NPV. This is the value of the discounted stream of incremental net benefit. Incremental net benefit refers to the difference between the incremental benefits and incremental costs due to CTBS use.

For all provinces, the NPVs are positive and decrease as the discount rate increases. The positive values of the incremental net benefits, even at the beginning of the projection and discounting period, imply that, unlike long-gestation projects, the benefits of using the CTBS are immediately realised. At the 10% discount rate, the average NPV for all provinces was A$1565 (VND14,639,547[9]). The highest NPV (A$3532 (VND33,045,494[9])) was computed for Vinh Phuc Province. This was followed by Binh Thuan Province, with a NPV of A$2142 (VND20,038,007[9]). The lowest NPV of A$130 (VND1,216,190[9]) was estimated for Bac Lieu (Table 6). The high value for Vinh Phuc may be attributed to the relatively high value of savings from avoided cost of plastic fence. For Binh Thuan, the high incremental value of rice yield contributed to the relatively high present value of the net incremental benefits. This may be attributed to the reported low rat population in the area, which accounted for higher yield. On the other hand, the low NPV for Bac Lieu may be due to the negative value of the incremental benefits from rice, wherein the non-CTBS users reported higher yields per hectare during the 2002–03 rice-cropping season than those who used CTBS. It may be that the land of non-CTBS users was more productive than that used by CTBS users, but this situation requires further investigation.

BCR. This is the ratio of the discounted incremental benefit to the discounted incremental cost. In all provinces, the BCRs were greater than 1.0. Using the 10% discount rate, the average BCR value was 21.58:1, with provincial values ranging from 2.44:1 in Soc Trang to 46.54:1 in Vinh Phuc (Table 6). This means that the benefits of using the CTBS with subsidy outweigh the costs incurred by the farmers. Since it is assumed that yields, prices, and costs are constant throughout the 10-year period, the change in the discount rate will not affect the BCR values. These values are somewhat lower than the values obtained by Singleton et al. (2004) in their assessment of the ACIAR rodent control project in Indonesia — the BCR was 25:1 on average, with values ranging from –1.8:1 to 63:1. The relatively higher values obtained in the Indonesian assessment may be because the results were based on experiments, whereas this study was based on the responses of the farmers about their own experiences with CTBS adoption. In addition, this study made

[9] A$1 = VND9356, which is the average conversion rate for 2002–2003.

projections and discounting of the stream of benefits and costs (the Singleton et al. (2004) study was based on the results of the three-year experiment without projection and discounting).

Table 6. Financial feasibility indicators of community trap–barrier system (CTBS) adoption with subsidy, by province, Vietnam (NPV = net present value; BCR = benefit–cost ratio)

Province	NPV						BCR
	5%		10%		15%		10%
	A$	VND	A$	VND	A$	VND	
Vinh Phuc	4438	41,527,506	3532	33,045,494	2885	26,990,948	46.54
Binh Thuan	2691	25,181,298	2142	20,038,007	1749	16,366,673	17.12
Soc Trang	185	1,730,209	147	1,376,813	120	1,124,555	2.44
Tien Giang	2353	22,018,527	1873	17,521,233	1530	14,311,019	35.56
Bac Lieu	167	1,528,358	130	1,216,190	106	993,362	6.25
All provinces	1966	18,397,180	1565	14,639,547	1278	11,957,311	21.58

Note: Details of the benefit–cost analysis by province are shown in Appendix Tables A2a–A2f.
A$1 = VND9356, which is the average conversion rate for 2002–03.

The farmers who have experienced the CTBS agree that the technology is effective; however, its adoption has been slow because of the costs involved. Because of their low income, farmers do not have the capacity to shoulder the cost of the materials. This problem can be minimised if the farmers' association or cooperative is strong. The farmers in Bac Binh, Binh Thuan Province, are ready to adopt the CTBS technology. Their cooperative will take care of the cost of the materials and the members will take care of the labour requirements of CTBS set-up and monitoring. After harvest, all the costs involved will be computed by the cooperative and the farmers covered by the CTBS will share the cost equally. For those associations with limited capital, the PPD may help them obtain credit from the government or bank, to be paid after the harvest. The farmers in northern Vietnam (Vinh Phuc Province) also mentioned that they could use their cooperative to manage the CTBS. According to the farmers, 'free-riding' should not be a problem since farmers are governed, and abide, by the rules of their cooperative.

The farmers mentioned other benefits that are not included in this financial analysis, such as environmental safety of using the CTBS. Farmers mentioned that before introduction of the system, they were using rodenticides that were so toxic that non-target animals such as dogs and cats were being killed.

5.5 Sensitivity analysis

The BCA above considered the situation in which CTBS use is subsidised by either donor organisations or the government. In a real situation, however, subsidy for the use of the technology cannot be given in perpetuity — hence, once the technology is adopted, the farmers or users have to pay for the cost associated with its use. For the CTBS, assuming yield, prices, and cost remain constant, would its use still be profitable for the farmers if no subsidy were given? To answer this question, a sensitivity analysis on the use of CTBS without subsidy was carried out.

Results of the sensitivity analysis showed that, except for Soc Trang, where the NPV is negative and BCR less than one, the use of CTBS without subsidy would still be financially viable in all provinces. At a 10% discount rate, the average NPV was A$1454 (VND13,605,066[10]) (Table 7), which was only slightly lower than the situation when CTBS is subsidised. The negative effect of the CTBS in Soc Trang may be attributed to the high cost of rodenticide reported by the farmers and not to the materials for CTBS. As shown in Appendix Tables 1c and 1d, the cost of the CTBS in Soc Trang and Tien Giang was almost the same, but the two provinces differed in rodenticide costs. Thus, if no subsidy is given for CTBS use, the cost of rodent control in Soc Trang is higher than in the other provinces. With no subsidy, although the BCR values for the other four provinces would be positive, the values would be much lower than if the subsidy were given. This situation indicates that, other things being constant, the full cost of CTBS adoption would reduce the profitability of rice farming. Thus, a modified, cheaper CTBS set-up is necessary and needs further investigation.

Since the objective of the analysis was to study the financial impact of the technology on farmers, the foregoing analysis was carried out on a per hectare basis. No attempt was made to scale-up the analysis to the provincial level, as farmers adopt the technology only when they feel it necessary, i.e. when they perceive an increase in the rodent population. In addition, the technology has no fixed cost component on a yearly basis since the materials have to be changed every year and increased/decreased adoption would entail a proportionate increase/decrease in costs.

[10]A$1 = VND9356, which is the average conversion rate for 2002–03.

Table 7. Results of the sensitivity analysis of using the community trap–barrier system (CTBS) without subsidy, by province, Vietnam

Province	NPV (amounts in VND)						BCR
	5%		10%		15%		10%
	A$	VND	A$	VND	A$	VND	
Vinh Phuc	4313	40,352,984	3432	32,110,889	2803	26,227,563	20.34
Binh Thuan	2642	24,717,994	2102	19,669,333	1717	16,065,547	13.21
Soc Trang	50	(470,485)	40	(374,388)	33	(305,794)	0.86
Tien Giang	2112	19,763,008	1681	15,726,405	1373	12,845,036	7.83
Bac Lieu	120	1,122,326	95	893,090	78	729,460	2.61
All provinces	1827	17,097,165	1454	13,605,066	1188	11,112,362	8.97

Note: Details of the sensitivity analysis (without CTBS subsidy) by province are shown in Appendix Tables A3a–A3f.
A$1 = VND9356, which is the average conversion rate for 2002–03.

6 Conclusions

Considering that rats are a part of Vietnam's food culture, ecologically based rodent management technologies such as the CTBS and IRM-V are appropriate for adoption. Although farmers are adopting the CTBS only slowly, most of the components of IRM-V have already been an integral part of farmers' practices in controlling rodents, particularly in the north.

Despite the relatively slow adoption of the CTBS, some indicators point to a wider and sustained adoption of both the CTBS and IRM-V. These include:

- the national policy direcive to farmers to practise IRM-V, including CTBS use
- the provincial-level budget allocation for the implementation of the policy, which will result in more CTBS demonstrations and implementation of IRM-V in other provinces
- the adoption of the technology by individual farmers with a larger farm size and a high rodent population using their own resources
- the integrated use of CTBS and IRM-V by World Vision in their area development programs in the country
- the practice of monoculture farming (rice only), good irrigation facilities, large farm size, high rodent population, strong farmers'

cooperatives/associations/IPM clubs, partial subsidy, and capacity-building

- the potential improvements in environmental and health conditions, and more cohesive interaction among community members
- the low cost of CTBS. Even though farmers repeatedly stated that the high cost of the CTBS constrained them from using the technology, a CTBS that can cover 10–15 ha would entail around only 2% of the total production cost on a per hectare basis.
- the positive impact the adoption of the rodent control methods have on the welfare of farmers in terms of financial benefits (as shown by the results of the farm-level BCA) even if the use of the CTBS is not subsidised.

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Appendix

Table A1a. Itemised production cost (VND/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), Me Linh District, Vinh Phuc Province, northern Vietnam, 2002–03

Item	With CTBS			Without CTBS		
	Spring	Summer	Total	Spring	Summer	Total
Land preparation	824,733	836,334	1,661,067	833,400	833,400	1,666,800
Seed	155,000	155,000	310,000	150,000	150,000	300,000
Fertiliser	912,189	925,723	1,837,912	850,000	850,000	1,700,000
Manure	801,143	801,143	1,602,286	850,000	850,000	1,700,000
Rodenticide	52,473	53,633	106,106	83,340	83,340	166,680
Pesticide	550,000	563,534	1,113,534	555,600	555,600	1,111,200
Transplanting	400,000	400,000	800,000	416,700	416,700	833,400
Harvesting	600,000	600,000	1,200,000	500,000	500,000	1,000,000
Threshing	250,000	250,000	500,000	277,800	277,800	555,600
Irrigation	749,822	757,556	1,507,378	555,600	555,600	1,111,200
Service	996,993	1,019,034	2,016,027	1,583,460	1,583,460	3,166,920
Plastic fence	2,222,400	2,222,400	4,444,800	1,760,767	1,760,767	3,521,534
Subtotal	8,514,753	8,584,357	17,099,110	8,416,667	8,416,667	16,833,334
Cost of CTBS						
With subsidy	6000	6000	12,000			
Without subsidy	82,053	82,053	164,106			
Total cost with subsidy	8,520,753	8,590,357	17,111,110			
Total cost without subsidy	8,596,806	8,666,410	17,263,216			

Note: The cost of plastic fence with the CTBS is entered as a benefit in the benefit–cost analysis.
Costs are in VND/ha. A$1 = VND9356.

Table A1b. Itemised production cost (VND/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), Bac Binh District, Binh Thuan Province, south-central Vietnam, 2002–03

	With CTBS			Without CTBS		
Item	Spring	Summer	Total	Spring	Summer	Total
Land preparation	905,350	738,255	1,643,605	835,500	827,167	1,662,667
Seed	740,741	604,027	1,344,768	675,500	667,167	1,342,667
Sowing	257,202	209,732	466,934	205,500	197,167	402,667
Pesticide	514,403	838,926	1,353,329	455,500	947,167	1,402,667
Fertiliser	411,523	335,570	747,093	355,500	347,167	702,667
Rodenticide	617,284	1,006,711	1,623,995	555,500	1,147,167	1,702,667
Replanting	462,963	377,517	840,480	405,500	397,167	802,667
Weeding	205,761	167,785	373,546	155,500	147,167	302,667
Harvesting	205,761	167,785	373,546	155,500	147,167	302,667
Threshing	205,761	167,785	373,546	155,500	147,167	302,667
Hauling	226,337	184,564	410,901	175,500	167,167	342,667
Drying	246,914	201,343	448,257	195,500	187,167	382,667
Subtotal	5,000,000	5,000,000	10,000,000	4,326,000	5,326,004	9,652,004
Cost of CTBS						
With subsidy	44,000	44,000	88,000			
Without subsidy	104,000	44,000	148,000			
Total cost with subsidy	5,044,000	5,044,000	10,088,000			
Total cost without subsidy	5,104,000	5,044,000	10,148,000			

Note: Costs are in VND/ha. A$1 = VND9356.

Table A1c. Itemised production cost (VND/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), My Tu District, Soc Trang Province, southern Vietnam, 2002–03

Item	With CTBS				Without CTBS			
	Summer–autumn	Winter–spring	Spring–summer	Total	Summer–autumn	Winter–spring	Spring–summer	Total
Land preparation	459,700	459,700	445,740	1,365,140	429,206	447,594	438,400	1,315,200
Seed	91,940	91,940	82,829	266,709	85,841	89,519	87,680	263,040
Fertiliser	1,072,692	1,072,692	966,389	3,111,773	855,012	898,399	876,706	2,630,117
Rodenticide	12,000	12,000	12,000	36,000	157,690	157,690	157,690	473,070
Pesticide*	306,466	306,466	306,466	919,398	286,137	298,396	292,267	876,800
Transplanting	229,850	229,850	207,072	666,772	214,603	223,797	219,200	657,600
Harvesting	306,466	306,466	276,096	889,028	286,137	298,396	292,267	876,800
Threshing	153,233	153,233	138,048	444,514	143,069	149,198	146,133	438,400
Irrigation	691,154	691,154	622,661	2,004,969	645,306	672,953	659,130	1,977,389
Service	522,652	522,652	407,701	1,453,005	488,020	508,928	498,474	1,495,422
Subtotal	3,846,153	3,846,153	3,465,002	11,157,308	3,591,021	3,744,870	3,667,947	11,003,838
Cost of CTBS								
With subsidy	40,000	40,000	40,000	120,000				
Without subsidy	132,000	140,000	133,000	405,000				
Total cost with subsidy	3,886,153	3,886,153	3,505,002	11,277,308				
Total cost without subsidy	3,978,153	3,986,153	3,598,002	11,562,308				

Note: Costs are in VND/ha. A$1 = VND9356.

Table A1d. Itemised production cost (VND/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), Cai Be District, Tien Giang Province, southern Vietnam, 2002–03

Item	With CTBS				Without CTBS			
	Winter–spring	Spring–summer	Summer–autumn	Total	Winter–spring	Spring–summer	Summer–autumn	Total
Land preparation	597,564	561,753	510,850	1,670,167	558,167	536,653	435,060	1,529,880
Seed	119,522	112,351	95,618	327,491	111,633	107,331	87,012	305,976
Fertiliser	1,356,000	1,272,107	1,077,100	3,705,207	1,293,222	1,242,914	999,347	3,535,483
Rodenticide	3,000	3,000	3,000	9,000	12,000	12,000	18,000	42,000
Pesticide	455,000	427,700	364,000	1,246,700	424,970	408,590	331,240	1,164,800
Transplanting	298,805	280,876	239,044	818,725	279,084	268,327	217,530	764,941
Harvesting	398,406	374,502	318,725	1,091,633	372,112	357,769	290,040	1,019,921
Threshing	199,203	187,251	159,363	545,817	186,056	178,884	145,020	509,960
Irrigation	898,500	844,590	718,800	2,461,890	839,199	806,853	654,108	2,300,160
Service	635,500	597,370	475,000	1,707,870	593,557	570,679	462,643	1,626,879
Subtotal	4,961,500	4,661,500	3,961,500	13,584,500	4,670,000	4,490,000	3,640,000	12,800,000
CTBS								
With subsidy	38,500	38,500	38,500	115,500				
Without subsidy	38,500	138,100	225,000	401,600				
Total cost with subsidy	5,000,000	4,700,000	4,000,000	13,700,000				
Total cost without subsidy	5,000,000	4,799,600	4,186,500	13,986,100				

Note: Costs are in VND/ha. A$1 = VND9356.

Table A1e. Itemised production cost (VND/ha) according to community trap–barrier system use ('with CTBS' and 'without CTBS'), Vinh Loi District, Bac Lieu Province, southern Vietnam, 2002–03

Item	With CTBS			Without CTBS		
	Summer–autumn	Autumn–winter	Total	Spring	Summer	Total
Land preparation	597,610	657,371	1,254,981	597,610	633,466	1,231,076
Seed	119,522	131,474	250,996	119,522	126,693	246,215
Fertiliser	1,394,500	1,533,950	2,928,450	1,279,090	1,355,835	2,634,925
Rodenticide	6,000	9,000	15,000	123,000	130,380	253,380
Pesticide*	452,000	497,200	949,200	450,500	477,530	928,030
Transplanting	299,000	328,900	627,900	298,805	316,733	615,538
Harvesting	398,500	438,350	836,850	398,406	422,311	820,717
Threshing	199,000	218,900	417,900	199,203	211,155	410,358
Irrigation	1,198,500	1,238,350	2,436,850	998,406	1,022,311	2,020,717
Service	335,368	446,505	781,873	535,458	603,586	1,139,044
Subtotal	5,000,000	5,500,000	10,500,000	5,000,000	5,300,000	10,300,000
Cost of CTBS						
With subsidy	22,667		22,667			
Without subsidy	75,250		75,250			
Total cost with subsidy	5,022,667	5,500,000	10,522,667			
Total cost without subsidy	5,075,250	5,500,000	10,575,250			

Note: CTBS was used for the summer–autumn season only.
Costs are in VND/ha. A$1 = VND9356.

Table A2a. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, Me Linh District, Vinh Phuc Province, northern Vietnam

Year	Incremental benefits with CTBS				Incremental cost with subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from plastic fence and rodenticide	Total incremental benefits		
1	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
2	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
3	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
4	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
5	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
6	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
7	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
8	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
9	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
10	1,846,000	80,000	3,570,108	5,496,108	118,106	5,378,002
			BCR (5%)	46.54		
			BCR (10%)	46.54		
			BCR (15%)	46.54		
			NPV (5%)			41,527,506
			NPV (10%)			33,045,494
			NPV (15%)			26,990,948

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A2b. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, Bac Binh District, Bin Thuan Province, south-central Vietnam

Year	Incremental benefits with CTBS			Incremental cost with subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Total incremental benefits		
1	3,400,000	63,333	3,463,333	202,240	3,261,093
2	3,400,000	63,333	3,463,333	202,240	3,261,093
3	3,400,000	63,333	3,463,333	202,240	3,261,093
4	3,400,000	63,333	3,463,333	202,240	3,261,093
5	3,400,000	63,333	3,463,333	202,240	3,261,093
6	3,400,000	63,333	3,463,333	202,240	3,261,093
7	3,400,000	63,333	3,463,333	202,240	3,261,093
8	3,400,000	63,333	3,463,333	202,240	3,261,093
9	3,400,000	63,333	3,463,333	202,240	3,261,093
10	3,400,000	63,333	3,463,333	202,240	3,261,093
		BCR (5%)	17.12		
		BCR (10%)	17.12		
		BCR (15%)	17.12		
		NPV (5%)			25,181,298
		NPV (10%)			20,038,007
		NPV (15%)			16,366,673

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A2c. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, My Tu District, Soc Trang Province, southern Vietnam

Year	Benefits with CTBS				Incremental cost with subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from rodenticide	Total incremental benefits		
1	0	63,000	317,070	380,070	156,000	224,070
2	0	63,000	317,070	380,070	156,000	224,070
3	0	63,000	317,070	380,070	156,000	224,070
4	0	63,000	317,070	380,070	156,000	224,070
5	0	63,000	317,070	380,070	156,000	224,070
6	0	63,000	317,070	380,070	156,000	224,070
7	0	63,000	317,070	380,070	156,000	224,070
8	0	63,000	317,070	380,070	156,000	224,070
9	0	63,000	317,070	380,070	156,000	224,070
10	0	63,000	317,070	380,070	156,000	224,070
			BCR (5%)	2.44		
			BCR (10%)	2.44		
			BCR (15%)	2.44		
			NPV (5%)			1,730,209
			NPV (10%)			1,376,813
			NPV (15%)			1,124,555

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A2d. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, Cai Be District, Tien Giang Province, southern Vietnam

Year	Incremental benefits with CTBS			Incremental cost with subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Total incremental benefits		
1	2,880,000	54,000	2,934,000	82,500	2,851,500
2	2,880,000	54,000	2,934,000	82,500	2,851,500
3	2,880,000	54,000	2,934,000	82,500	2,851,500
4	2,880,000	54,000	2,934,000	82,500	2,851,500
5	2,880,000	54,000	2,934,000	82,500	2,851,500
6	2,880,000	54,000	2,934,000	82,500	2,851,500
7	2,880,000	54,000	2,934,000	82,500	2,851,500
8	2,880,000	54,000	2,934,000	82,500	2,851,500
9	2,880,000	54,000	2,934,000	82,500	2,851,500
10	2,880,000	54,000	2,934,000	82,500	2,851,500
		BCR (5%)	35.56		
		BCR (10%)	35.56		
		BCR (15%)	35.56		
		NPV (5%)			22,018,527
		NPV (10%)			17,521,233
		NPV (15%)			14,311,019

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A2e. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, Vinh Loi District, Bac Lieu Province, southern Vietnam

Year	Incremental benefits with CTBS				Incremental cost with subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from rodenticide	Total incremental benefits		
1	(400)	20,583	215,413	235,596	37,667	197,929
2	(400)	20,583	215,413	235,596	37,667	197,929
3	(400)	20,583	215,413	235,596	37,667	197,929
4	(400)	20,583	215,413	235,596	37,667	197,929
5	(400)	20,583	215,413	235,596	37,667	197,929
6	(400)	20,583	215,413	235,596	37,667	197,929
7	(400)	20,583	215,413	235,596	37,667	197,929
8	(400)	20,583	215,413	235,596	37,667	197,929
9	(400)	20,583	215,413	235,596	37,667	197,929
10	(400)	20,583	215,413	235,596	37,667	197,929
			BCR (5%)	6.25		
			BCR (10%)	6.25		
			BCR (15%)	6.25		
			NPV (5%)			1,528,358
			NPV (10%)			1,216,190
			NPV (15%)			993,362

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A2f. Benefit–cost analysis for using the community trap–barrier system (CTBS) with subsidy, average of five provinces, Vietnam

Year	Incremental benefits						Incremental cost without subsidy						Incremental net benefit
	Vinh Phuc	Binh Thuan	Soc Trang	Tien Giang	Bac Lieu	Average	Vinh Phuc	Binh Thuan	Soc Trang	Tien Giang	Bac Lieu	Average	
1	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
2	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
3	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
4	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
5	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
6	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
7	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
8	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
9	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
10	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	118,106	202,240	156,000	82,500	37,667	119,303	2,382,519
						BCR (5%)	20.97						
						BCR (10%)	20.97						
						BCR (15%)	20.97						
						NPV (5%)							18,397,180
						NPV (10%)							14,639,547
						NPV (15%)							11,957,311

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3a. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, Me Linh District, Vinh Phuc Province, northern Vietnam

Year	Incremental benefits with CTBS				Incremental cost without subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from plastic fence and rodenticide	Total incremental benefits		
1	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
2	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
3	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
4	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
5	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
6	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
7	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
8	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
9	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
10	1,846,000	80,000	3,570,108	5,496,108	270,212	5,225,896
			BCR (5%)	20.34		
			BCR (10%)	20.34		
			BCR (15%)	20.34		
			NPV (5%)			40,352,984
			NPV (10%)			32,110,869
			NPV (15%)			26,227,563

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3b. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, Bac Binh District, Binh Thuan Province, south-central Vietnam

Year	Incremental benefits with CTBS			Incremental cost without subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Total incremental benefits		
1	3,400,000	63,333	3,463,333	262,240	3,201,093
2	3,400,000	63,333	3,463,333	262,240	3,201,093
3	3,400,000	63,333	3,463,333	262,240	3,201,093
4	3,400,000	63,333	3,463,333	262,240	3,201,093
5	3,400,000	63,333	3,463,333	262,240	3,201,093
6	3,400,000	63,333	3,463,333	262,240	3,201,093
7	3,400,000	63,333	3,463,333	262,240	3,201,093
8	3,400,000	63,333	3,463,333	262,240	3,201,093
9	3,400,000	63,333	3,463,333	262,240	3,201,093
10	3,400,000	63,333	3,463,333	262,240	3,201,093
		BCR (5%)	13.21		
		BCR (10%)	13.21		
		BCR (15%)	13.21		
		NPV (5%)			24,717,994
		NPV (10%)			19,669,333
		NPV (15%)			16,065,547

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3c. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, My Tu District, Soc Trang Province, southern Vietnam

Year	Incremental benefits with CTBS				Incremental cost without CTBS	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from rodenticide	Total incremental benefits		
1	0	63,000	317,070	380,070	441,000	(60,930)
2	0	63,000	317,070	380,070	441,000	(60,930)
3	0	63,000	317,070	380,070	441,000	(60,930)
4	0	63,000	317,070	380,070	441,000	(60,930)
5	0	63,000	317,070	380,070	441,000	(60,930)
6	0	63,000	317,070	380,070	441,000	(60,930)
7	0	63,000	317,070	380,070	441,000	(60,930)
8	0	63,000	317,070	380,070	441,000	(60,930)
9	0	63,000	317,070	380,070	441,000	(60,930)
10	0	63,000	317,070	380,070	441,000	(60,930)
			BCR (5%)	0.86		
			BCR (10%)	0.86		
			BCR (15%)	0.86		
			NPV (5%)			(470,485)
			NPV (10%)			(374,388)
			NPV (15%)			(305,794)

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3d. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, Cai Be District, Tien Giang Province, southern Vietnam

Year	Benefits with CTBS			Incremental cost without subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Total incremental benefits		
1	2,880,000	54,000	2,934,000	374,600	2,559,400
2	2,880,000	54,000	2,934,000	374,600	2,559,400
3	2,880,000	54,000	2,934,000	374,600	2,559,400
4	2,880,000	54,000	2,934,000	374,600	2,559,400
5	2,880,000	54,000	2,934,000	374,600	2,559,400
6	2,880,000	54,000	2,934,000	374,600	2,559,400
7	2,880,000	54,000	2,934,000	374,600	2,559,400
8	2,880,000	54,000	2,934,000	374,600	2,559,400
9	2,880,000	54,000	2,934,000	374,600	2,559,400
10	2,880,000	54,000	2,934,000	374,600	2,559,400
		BCR (5%)	7.83		
		BCR (10%)	7.83		
		BCR (15%)	7.83		
		NPV (5%)			19,763,008
		NPV (10%)			15,726,405
		NPV (15%)			12,845,036

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3e. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, Vinh Loi District, Bac Lieu Province, southern Vietnam

Year	Incremental benefits with CTBS				Incremental cost without subsidy	Incremental net benefit
	Value of increased rice yield	Value of rats caught inside the CTBS	Cost savings from rodenticide	Total incremental benefits		
1	–400	20,583	215,413	235,596	90,250	145,346
2	–400	20,583	215,413	235,596	90,250	145,346
3	–400	20,583	215,413	235,596	90,250	145,346
4	–400	20,583	215,413	235,596	90,250	145,346
5	–400	20,583	215,413	235,596	90,250	145,346
6	–400	20,583	215,413	235,596	90,250	145,346
7	–400	20,583	215,413	235,596	90,250	145,346
8	–400	20,583	215,413	235,596	90,250	145,346
9	–400	20,583	215,413	235,596	90,250	145,346
10	–400	20,583	215,413	235,596	90,250	145,346
			BCR (5%)	2.61		
			BCR (10%)	2.61		
			BCR (15%)	2.61		
			NPV (5%)			1,122,326
			NPV (10%)			893,090
			NPV (15%)			729,460

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

Table A3f. Sensitivity analysis for using the community trap–barrier system (CTBS) without subsidy, average of five provinces, Vietnam

	Incremental benefits						Incremental cost without subsidy						Incremental net benefit
	Vinh Phuc	Binh Thuan	Soc Trang	Tien Giang	Bac Lieu	Average	Vinh Phuc	Binh Thuan	Soc Trang	Tien Giang	Bac Lieu	Average	
1	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
2	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
3	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
4	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
5	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
6	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
7	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
8	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
9	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
10	5,496,108	3,463,333	380,070	2,934,000	235,596	2,501,822	270,212	262,240	441,000	374,600	90,250	287,660	2,214,161
						BCR (5%)	8.70						
						BCR (10%)	8.70						
						BCR (15%)	8.70						
						NPV (5%)							17,097,165
						NPV (10%)							13,605,062
						NPV (15%)							11,112,362

Note: Cost and benefit values are in VND/ha. A$1 = VND9356.

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

IMPACT ASSESSMENT SERIES

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

ECONOMIC ASSESSMENT SERIES (DISCONTINUED)

No.	Author and year of publication	Title	ACIAR project numbers
1	Doeleman, J.A. (1990a)	Biological control of salvinia	8340
2	Tobin, J. (1990)	Fruit fly control	8343
3	Fleming, E. (1991)	Improving the feed value of straw fed to cattle and buffalo	8203 and 8601
4	Doeleman, J.A. (1990b)	Benefits and costs of entomopathogenic nematodes: two biological control applications in China	8451 and 8929
5	Chudleigh, P.D. (1991a)	Tick-borne disease control in cattle	8321
6	Chudleigh, P.D. (1991b)	Breeding and quality analysis of canola (rapeseed)	8469 and 8839
7	Johnston, J. and Cummings, R. (1991)	Control of Newcastle disease in village chickens with oral V4 vaccine	8334 and 8717
8	Ryland, G.J. (1991)	Long term storage of grain under plastic covers	8307
9	Chudleigh, P.D. (1991c)	Integrated use of insecticides in grain storage in the humid tropics	8309, 8609 and 8311
10	Chamala, S., Karan, V., Raman, K.V. and Gadewar, A.U. (1991)	An evaluation of the use and impact of the ACIAR book *Nutritional disorders of grain sorghum*	8207
11	Tisdell, C. (1991)	Culture of giant clams for food and for restocking tropical reefs	8332 and 8733
12	McKenney, D.W., Davis, J.S., Turnbull, J.W. and Searle, S.D. (1991)	The impact of Australian tree species research in China	8457 and 8848
	Menz, K.M. (1991)	Overview of Economic Assessments 1–12	