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1 Acknowledgments

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1.1 Acronyms

Acronym	Meaning
ADP	Area Development Program, part of World Vision Vietnam activities
AIAT	Assessment Institute for Agricultural Technology, South Sulawesi
APSIM	Agricultural Production systems SIMulator for computer modelling of crops
BCA	Benefit Cost Analysis, an economic analysis
BPH	Brown plant hoppers
BPTP	Balai Penkajian Teknologi Pertanian (refer to AIAT)
CA	Community Action for rodent management
CSIRO	Commonwealth Scientific and Industrial Research Organisation - refers to CSIRO Sustainable Ecosystems
CTBS	Community Trap-Barrier System for rodent management
Dinas	Refers here to Dinas Pertanian (Indonesian government agency charged with cropping)
DX1	Đông Xuân - Winter-Spring: 1st rice crop, dry season in Mekong River Delta, Vietnam
EBRM	Ecologically-based rodent management
FFS	Farmer Field School
FGD	Focus group discussion
FT1	Farm Type 1, used in economic modelling (average farm size of 2.5 ha)
FT2	Farm Type 2, used in economic modelling (average farm size of 5.1 ha)
HS1-3	Harvesting Season 1, equivalent to DX1; HS2, equivalent to HT2; HS3, equivalent to Vu3
HT2	Hè Thu - Summer-Autumn: 2nd rice crop, wet season in Mekong River Delta, Vietnam
IAS	Institute for Agricultural Sciences, Ho Chi Minh City, Vietnam
ICATAD	Indonesian Center for Agriculture Technology Assessment and Development
ICM	Integrated Crop Management
ICRBM	International Conference on Rodent Biology and Management
ICRR	Indonesian Centre for Rice Research, West Java, Indonesia
IP Padi 400	4 crops/year initiative, Indonesia
IPM	Integrated Pest Management
IRRI	International rice Research Institute
KAP&SE	Knowledge, Attitudes and Practices and Socio-Economic survey of farmers
KII	Key informant interviews
LTBS	Linear trap-barrier system for rodent management
NARES	National agricultural research and extension service
NGO	Non-government organisation
NIPP	National Institute for Plant Protection, Hanoi, Vietnam
P2BN	Policy initiative endorsed by President of Indonesia to increase rice production by 5%
PPD	Plant Protection Department, Vietnam
PPS	Plant Protection Station, Vietnam
Primatani	A pioneering program for accelerating dissemination of innovative technologies to develop rural agribusiness system, Indonesia
SADC	Southern African Development Community
TOT	Training of trainers
VND	Vietnamese Dong (Australian $1 = 16,000 VND)
Vu3	Vu - Autumn-Winter: 3rd rice crop, wet season in Mekong River Delta, Vietnam
WVV	World Vision Vietnam

2 Executive summary

Rodents remain a significant pest of lowland irrigated rice cropping systems throughout Southeast Asia causing around 15% yield loss to rice annually. Rodents are the number one pest of rice in Indonesia and one of the top three pests in Vietnam. Farmers describe rodents as the pest they have least control over. Traditionally, farmers have relied heavily on the use of rodenticides, electrocution and spreading sump oil mixed with insecticides onto flooded rice fields to manage the rodent problem, but these can be expensive, are often applied individually by farmers in an uncoordinated manner after significant damage has already occurred, and have environmental problems. Rodents affect households that are dependent on rice production for their livelihoods and impact on poor farming communities who have few resources.

This project was designed to implement ecologically-based rodent management (EBRM) which can reduce rat damage, increase yields and reduce the reliance on rodenticides. This project builds on the findings from previous ACIAR projects (AS1/1998/036). EBRM relies on an understanding of the ecology of rats which then governs better integrated Community Actions (CA; synchronised cropping, field and village hygiene, rat hunts at key times) and the Community Trap Barrier System (CTBS; plastic fence set with rat traps enclosing a small area of early planted rice). These approaches need community cooperation. Key issues are how to deliver EBRM to the wider farming community, develop extension materials, increase cost-effectiveness, build the capacity of support staff, and develop pathways to enhance the adoption of EBRM. The project was successful in delivering these and implementing EBRM.

Project activities occurred in lowland irrigated rice systems in Vietnam (Ha Nam province in the Red River Delta and An Giang province in the Mekong River Delta) and Indonesia (Karawang district West Java and Pinrang district in South Sulawesi). It involved a multidisciplinary team of research and extension agencies in Vietnam, Indonesia, Philippines and Australia.

Farming communities in each area were trained and supported in implementing EBRM from 2006. The approach used was the "training-of- trainers" (TOT) of local extension staff which was built up and expanded over the course of the project. Modules were integrated in national training programs. Training and supporting activities expanded from core sites each year and expanded to neighbouring villages and districts over each subsequent year (2007-2009). For example, EBRM activities expanded from 15 communes in Ha Nam Province in 2006 to 152 in 2009. Adoption and diffusion of EBRM was evident outside project areas. There were 17,000 farmers trained in Vietnam and 20,000 farmers trained in Indonesia. Farmer surveys, field observations and interviews were used to assess changes in farmer behaviour and activities.

The majority of farmers adopted CA as a successful rodent control strategy. The adoption of CTBS occurred only on sites where government subsidies were available to farmers. After implementing EBRM, rodent damage was reduced by 33-50% (reduced by up to 88% in Ha Nam Province), rice yields were increased by 2-5%, rodenticide use was reduced by 62-90%, and the use of electrocution was reduced by 95%. There was a strong shift away from individual actions to group or community actions.

Key findings to ensure sustainable EBRM include the need to have good coordination between civic and government agencies to enable farmer participation, strong, effective leadership of farmer groups is required, management needs to be conducted early in the growth of the rice crop before rodent populations commence breeding.

Community impacts include the increase participation of farmers and desire to involve community members to manage rats at a community/village level. There was also benefit of mutual management for rodents and brown plant hoppers in the Mekong Delta because of synchronised cropping. Economic impacts include the reduction in rodent damage leading to increased yields and subsequent increases in benefits for farming households. Social impacts include increased involvement within the farming community to bring a common benefit to the whole community through the rodent management, and involvement in communal rodent management with neighbouring villages. Environmental impacts include the significant reduction in use of rodenticides, plastic sheeting for protecting crops, and use of insecticides mixed with sump oil that was spread over paddy fields. There were 65 scientific reports and publications produced by the project.

This project has successfully demonstrated that it is possible to implement EBRM with farmers in lowland irrigated rice farming systems in Indonesia and Vietnam. To achieve effective and sustainable EBRM it is recommended to use Community Actions which incorporate synchronised cropping, field and village hygiene, rat hunts at key times, but they need to be supported by local and provincial governments.

3 Background

Rodents are significant pests of lowland irrigated rice crops throughout Southeast Asia. They have been regarded as the number 1 pre-harvest pest in Indonesia and one of the top three pests in Vietnam. In Indonesia, ricefield rats (*Rattus argentiventer*) are the most common species of rodent, causing 10-20% pre-harvest damage to rice crops (Geddes 1992). In Vietnam, about eight species of rodent are found in rice fields and are likely to cause damage, but the key rice pest is *Rattus argentiventer* (Brown et al. 2006), and crop damage is approximately 10% each year (Singleton 2003). In Vietnam, rodents are considered one of the three most important problems faced by the agricultural sector (Huynh 1987). In some years in some locations rodent damage can be up to 100% (Tuan et al. 2003). Other significant impacts include post-harvest losses, transmission of diseases to people and livestock (Meerburg et al. 2009), contaminating food and water, and damaging buildings and other possessions.

The level of rodent damage is more severe for poor rural households who lack the capacity to effectively absorb the losses and damage caused by rodents. Furthermore, this strongly affects households that are dependent on rice production for their livelihoods.

Rodents also cause significant damage to other cropping systems, such as lowland rainfed systems ("Ecologically-based management of rodents in rainfed cropping systems in Myanmar" SFS/2002/041), and upland rainfed rice farming systems ("A systems approach to rodent management in upland environments in Lao PDR" ADP/2004/016), but these agro-ecosystems are not covered in this project. We have made most progress on managing the lowland irrigated rice cropping system, particularly at the village-level (Singleton et al. 2005; Brown et al. 2006; Jacob et al. In Press). However, some of the key outcomes from this current project (ADP/2003/060) are likely to have spill-over benefits for other cropping systems.

Rice is a significant crop in Vietnam and Indonesia, both in terms of food security and for cultural and lifestyle reasons. Vietnam is the second largest exporter of rice globally which significantly contributes to their Gross Domestic Product (GDP). In Indonesia, there are strong drivers to achieve rice self-sufficiency as the human population increases and as the area for rice production is decreasing. Reducing the damage and yield loss caused by rodents will obviously have significant benefits for individual farmers but also to national food security in both Vietnam and Indonesia.

The project has had a long and distinguished development in Vietnam and Indonesia. This current project is the third in a line of projects that have addressed the problem of rodents in the lowland irrigated rice farming system, identified and tested a range of management strategies leading to some large-scale replicated field experiments at the village-level to develop recommendations for management.

1995-1997 (AS1/1994/20 & AS1/1996/79; "Management of rodent pests in Southeast Asia (& Vietnam))" - The key aims of this work was to describe the species of rat causing damage to rice fields, examine rat damage in rice fields, test management strategies including the rigorous assessment of the trap plus barrier system (TBS) and other management practices. There was also a strong emphasis on capacity building for in-country staff.

1999-2002 (AS1/1998/36 " Management of rodent pests in rice-based farming systems in Southeast Asia") - The key aims of this work was to field test a combination of Community Actions (CA) for rodent management in combination with the community trap barrier system (CTBS). In both Vietnam and Indonesia, large-scale replicated field studies were conducted over a 4-year period that involved farming communities in the testing and evaluation of the practices. There was a pre-treatment period, then 3 years of ecologically-based rodent management strategies were implemented. Assessments were made of the knowledge, attitudes and practices of farmers to rodent management, and economic assessments of management were conducted using benefit:cost ratios. Further capacity was built throughout this project. This led to the development of EBRM recommendations that were used in the current project (ADP/2003/060).

The review of AS1/1998/36 recommended:

- Design a project that focuses on delivery of EBRM strategies to wider community;
- Develop extension material on EBRM strategies;
- Increase (cost-) effectiveness of EBRM strategies;
- Incorporate capacity building component; and
- Develop pathways to enhance the adoption of EBRM strategies.

The focus of this current project (ADP/2003/060) was to take the findings of the village-level studies that were conducted in Vietnam and Indonesia, and to scale these out to other regions and districts within each of these countries, and to closely examine the diffusion pathways to enhance adoption and uptake of ecologically-based rodent management.

There was also an important change in the institutional leadership of the project for ADP/2003/060 in both Vietnam and Indonesia. In previous projects, the in-country lead agencies were research institutions (Vietnam: NIPP and IAS; Indonesia: ICRR), but the new project (ADP/2003/060) is led by extension agencies in both countries (Vietnam: PDD; Indonesia: ICATAD). This reflects the change in the nature of the project from ecological assessment of rodent management to a situation to examine the social and economic constraints of adoption and sustainable implementation of rodent management.

One key outcome of the previous work was the capacity development of key staff and institutions in both Indonesia and Vietnam. Although the focus of this project (ADP/2003/060) had been towards extension, the key research institutions in Vietnam and Indonesia have continued to play a key role in this project. This is a testament to the on-going commitment of the ACIAR funding, but also the willingness and drive of the in-country institutions and staff to tackle a significant problem in their respective countries.

Based on the outcomes of AS1/1998/36, community-based rodent management strategies were targeted through:

Community Action (CA) - this is a combination of a number of activities that farming communities were encouraged to work together to implement:

- *Village campaigns* in the fields and villages early in the rice crop growth stages (before maximum tillering stage) to kill rats before they start breeding and to work together to control rats together over large area and minimise reinvasion;
- *Synchronise planting and harvesting of crops* to keep the breeding season of rats short;
- *Field sanitation* to keep fields clean of weeds and piles of straw that provide good habitat and food resources for rodents; and
- *Keep bund size small* between paddy fields (< 30 cm high and < 30 cm wide) to stop rats building burrows in the fields.

Community Trap Barrier System (CTBS) -

- CTBS set up 2 to 3 weeks prior to planting of surrounding crops, surrounded by plastic fence (minimum size of 20 m x 20 m) and set with multiple capture rodent traps. It was recommended that 1 CTBS be set for every 10 ha of land and positioned near good rodent habitat where rodent damage was likely and also where farmers have easy access to check the traps and condition of the fence every day. This technology was promoted only in regions with chronic rodent losses and in the seasons when this occurs (e.g. dry season in West Java).

The key issues that were to be addressed in the current project (ADP/2003/060) were:

- Understand how community-based management recommendations could be incorporated within existing structures;
- Understand the social and economic constraints that might enable farmers to take up the technologies;
- Enable functional institutional arrangements that allow effective communication to facilitate delivery of technologies through to influencing Government policy;
- Provide joint ownership of projects (farmers through to government officials);
- Improve farmers livelihoods through adoption of EBRM strategies;
- Develop efficient extension networks; and
- Involve NGOs to assist with regional adoption of EBRM.

The current project was set up in four regions, two each in Vietnam and Indonesia. These were An Giang province (Mekong River Delta) and Ha Nam province (Red River Delta) in Vietnam, and Karawang District (West Java) and Pinrang District (South Sulawesi) in Indonesia. While all these are lowland irrigated rice cropping systems, they each are different, such that the findings from this project can demonstrate the utility and robustness of ecologically-based rodent management strategies over a range of lowland irrigated rice agro-ecosystems.

Towards the end of the project (May 2009), a review of the project was conducted in Vietnam and Indonesia. This led to a series of recommendations for the project team. As a result of the review, an additional six months was granted to complete the project, but no additional funding was given. The recommendations were:

Recommendation 1: That ACIAR supports a project extension if required to complete all reports and fully document important processes in the EBRM adoption pathway. This may include a ‘writing workshop’ for key project staff to finish writing reports and science papers. The Director of the ICATAD is very mindful of the need for science (including social-science) publications from this project. Presentation at the 4th ICRBM in South Africa provides an immediate and relevant outlet for the science.

Recommendation 2: That ACIAR provide financial support for a Final Workshop before the project term ends for Project staff and relevant end users.

Recommendation 3: That the relevant government departments and institutes (PPD, ICATAD and IRRC) write a Dissemination Strategy to effectively communicate the steps needed for EBRM to be adopted in new regions. The help of IRRI and CSIRO staff may be necessary. The translation of manuals and the Integrative Modelling package to local languages is also required.

Recommendation 4: That key individuals in the relevant government departments and institutes meet and prepare documents that can be used by policy makers in the respective countries.

Recommendation 5: That ACIAR and project leaders have the opportunity to identify and propose future research needs at the completion of this project.

4 Objectives

Objective 1. To work with farmer communities that face severe rodent impacts, to develop incentives that enhance cohesive community participation in integrated ecologically-based rodent management (EBRM) with at least 70% farmer participation.

Activities:

1.1 Develop baseline profile of 4 villages in districts for adoption and diffusion of EBRM. Impacts on farmers at household and community level will be measured and assessed against set targets, using both qualitative and quantitative performance indicators.

1.2 Develop EBRM demonstration villages for foci for spread of rodent management technology.

1.3 Record on and off-farm inputs and outputs of agricultural and non agricultural economic activities incorporating farmer diaries to measure changes in practices and economic costs and benefits at the farm household level.

Objective 2. To build on experiences from previous projects to develop a functional institutional framework for project implementation at national, provincial and district levels and maintain effective communication across all agencies.

Activities:

2.1 Establish efficient and functional institutional linkages that facilitate access to and delivery of technology to communities of farmers. In Indonesia advisory and technical steering groups will be established.

2.2 Effective communication achieved through annual coordination meetings, regular contact with key staff and farmer groups, and promotion of EBRM through media, brochures and farmer group (eg farmer field schools, IPM clubs).

Objective 3. Develop and implement effective incentive and communication strategies and establish active linkages with local and national government to mobilise mass Community Actions against rats for strategic intervention, where the timing of actions will be based on the rodent ecology of the specific regions.

Activities:

3.1 Incorporate EBRM into regional extension networks at the provincial level. Develop and implement incentive schemes and communication strategies through active linkages with existing (in-) formal institutions, local and national government. Mobilise community campaigns against rats for strategic intervention where timing of these campaigns will be based on the rodent ecology of the specific regions.

3.2 Assess the economic, social and environmental impacts of EBRM at the community and regional level.

3.3 Measure the rate of diffusion of the technology at a district and regional level, and determine whether farming communities are likely to sustain their use of these technologies. This analysis will differentiate for types of farm households and villages, in order to assess the variability in adoption behaviour amongst farmers and villages.

Objective 4. To further develop extension materials and train NARES and NGO partners in rodent biology, EBRM and methodologies to facilitate adoption of technologies.

Activities:

4.1 Based on a general handbook for Asia and Pacific published in 2003, develop handbooks in Indonesian and Vietnamese on rodent biology and management for NARES and NGO partners. Develop curriculum for train the trainers (key farmers, provincial AIAT staff (Indonesia) and sub PPD staff (Vietnam), NGO staff) and requisite brochures to support extension activities at the community and regional level.

4.2 Involve NGOs (World Vision Vietnam; various in Indonesia) to assist with the regional adoption of pathways of EBRM.

5 Methodology

5.1 Location of activities in Vietnam

5.1.1 Study location in Vietnam

This project was located in two key areas where lowland irrigated rice is grown and rodents have been identified as a significant constraint to production. Rice is grown in many areas throughout Vietnam, but the two principal areas are the Red River Delta, in northern Vietnam, and the Mekong River Delta, in southern Vietnam, which are large low-lying areas with good soil and water resources. Three rice crops per year are possible in the Mekong Delta because of access to irrigation water and ideal tropical monsoonal climate conditions. Average yields in the Mekong delta are 4 to 8 tonnes/ha. In the Red River Delta, two rice crops are generally grown per year, with yields of around 5.2 t/ha in the first rice crop (Spring) and yields of around 4.8 t/ha in the second crop (Summer). The more temperate climate conditions in the northern part of the country, means that the winter season is too cool to allow sufficient growth and development of rice crops, and so other crops are grown at that time such as vegetables.

The two areas identified were Ha Nam province, south west of Hanoi in the Red River Delta, and An Giang province in the Mekong River Delta (Figure 5.1). Both areas experience chronic rodent problems. These were typical intensive lowland irrigated rice cropping systems and were similar in nature to those that were intensively studied in the previous ACIAR rodent project (AS1/1998/036) in Vinh Phuc (Brown et al. 2006), so the project team was reasonably confident that there was a reasonable chance of success. Furthermore, there were good extension networks and linkages with relevant institutions and a strong willingness to be involved in the project by farmers and local authorities, which was confirmed after initial visits by the project team through key informant interviews (KII) and focus group discussions (FGD).

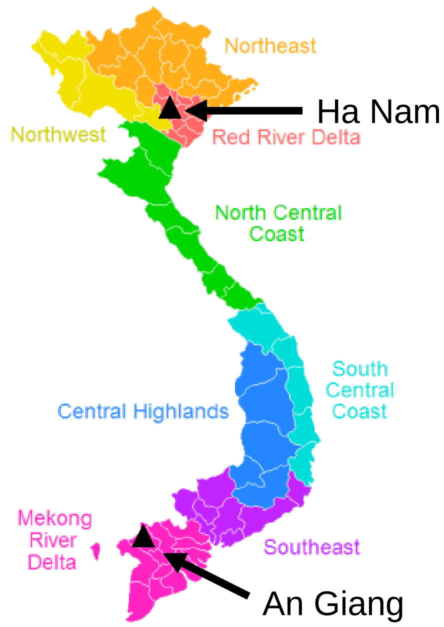

Figure 5.1. Location of Ha Nam province in the Red River Delta and An Giang province in the Mekong River Delta, Vietnam.

5.1.2 Farming system and cropping calendars in Vietnam

Ha Nam Province

The project was conducted in Dong Hoa Commune, Ha Nam Province. The farming population is 9,500, with 2,500 households, and an area of rice production of 530 ha. The spring rice yield is 6.2 t/ha, summer rice yield is 5.4 t/ha, and winter crops include cabbage, maize, and soybean. There is normally low rat damage during spring rice crop, medium damage during summer rice and high damage in winter crops (Table 5.1).

Table 5.1. Cropping calendar for Dong Hoa Commune, Kim Bang District, Ha Nam Province, showing planting (P) and harvesting (H) timings and when serious rodent damage occurs (***).

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Spring rice	P	→	→	→	→	H						
Summer rice							P	→	→	H		
Winter veg										P	→	H
Rat damage				***				***		***		

An Giang Province

The study was conducted in Tri Ton and Tinh Bien District. These sites were about 2 km from the Cambodian border. The first rice crop yields 5.5 – 6.0 t/ha, the second rice crop yields about 4.5 t/ha. About 60% of land is planted to cucumber in the third season. One farmer claimed he could achieve rice yields of 7 t/ha. There is low rat damage during first rice crop, high damage from booting stage onwards for second rice crop, and high damage prior to harvest of cucumber (Table 5.2). There is widespread flooding in this area from approximately mid-July to mid-September each year.

Table 5.2. Cropping calendar for Tri Ton District, An Giang Province, showing planting (P) and harvesting (H) timings and when serious rodent damage occurs (***).

Crop	J	F	M	A	M	J	J	A	S	O	N	D
1st rice crop	→	H						Flood	Flood	P	→	→
2nd rice crop				P	→	→	H					
Cucumber		P	→	H								
Rat damage				***		***	***					

There were two broad farmer types identified in An Giang Province, based on data from the KAP&SE survey. Farm Type 1 had a farm area of 2.5 ha, a family size of 4.7 and had 18.4 years of farming experience. They had a large investment in livestock. Farm Type 2 had a farm area of 5.1 ha, a family size of 4.8 and had 20.5 years of farming experience. They had a small investment in livestock. These farm types will be further discussed as part of an economic model described in Section 5.3.7 and results presented in Section 7.5.2.

5.1.3 Implementation of treatments in Vietnam

In Vietnam, the original implementation of treatments was set out following two levels of EBRM treatment and control (where no EBRM was applied; alternately known as reference sites). These were established and implemented in June 2006:

- *Treatment 1*: CTBS and Community Action demonstration site, thus establishing a CTBS in combination with synchronised cropping, timed community campaigns and field hygiene.
- *Treatment 2*: Community Action demonstration site, thus applying synchronised cropping, timed community campaigns and field hygiene only.
- *Control*: no EBRM strategies applied - farmers continued to conduct their existing rodent management strategies.

Over time (from 2007/08 onwards), these "treatments" evolved such that there was little difference between the two levels of treatment. In addition, some farmers on the control sites showed interest in the EBRM strategies and effectively became treatment sites.

In the final year of the field implementation (2009), nearly all villages were considered as Treatment, with most implementing Treatment 2 activities (largely the Community Actions), with some CTBS still active.

The following tables describe the sampling procedure (total population and sample size in treatment and control communes/hamlets) and the timing of the KAP&SE survey in An Giang and Ha Nam province, respectively (Tables 5.3 and 5.4).

Table 5.3. Treatment/control communes and hamlets in An Giang province, Vietnam

Village (name)	Farmer group (name)	Area (ha)	Type of site	Members (#)	Sample size
Tri Ton district					
Lac Quoi		*400*	*Treatment*	*260*	*70*
	Vinh Quoi & Vinh Thuan	172	Treatment 1	112	35
	Vinh Hoa & Vinh Phu	228	Treatment 2	148	35
Vinh Gia		*400*	*Control*	*434*	*50*
	Vinh Lac	72	Control	78	9
	Vinh Cau	87	Control	94	11
	Vinh Hoa	110	Control	119	14
	Vinh Hiep	132	Control	143	16
Tinh Bien district					
An Nong		*1000*	*Treatment*	*184*	*70*
	Phu Cuong	326	Treatment 1	60	35
	An Bien & Tan Bien	674	Treatment 2	124	35
Nhon Hung		*400*	*Control*	*231*	*50*
	Trung Bac Hung	73	Control	42	9
	Tay Hung	104	Control	60	13
	Dong Hung	223	Control	129	28

Table 5.4. Treatment/control communes and hamlets in Ha Nam province, Vietnam

Village (name)	Farmer group (name)	Area (ha)	Type of site	Members (#)	Sample size
Binh Luc district					
Mai Luong cooperative		*216*		*788*	*70*
	Mai Dong	81	Treatment 1	320	35
	Ben	56	Control	190	8
	Thuong Dong	49	Control	167	14
	Cau	30	Control	111	13
Binh Minh cooperative		*324*		*974*	*70*
	Vy Thuong	67	Treatment 1	159	7
	Vy Ha	79	Treatment 1	234	10
	Cua	54	Treatment 1	159	6
	Cua Trai	25	Treatment 1	77	3
	Duy Duong	63	Treatment 1	216	9
	Dong Quan	36	Control	129	35
Kim Bang district					
Ngoc Son		*308*		*1439*	*70*
	Thuy Xuyen	49	Treatment 1	229	7
	Ma Nao	120	Treatment 1	546	17
	Phuong Ke	83	Treatment 1	344	11
	Danh Xa	56	Control	320	35
Le Ho		*468*		*1800*	*70*
	Phuong Thuong	200	Treatment 1	943	21
	An Dong	93	Treatment 1	232	5
	Dong Thai	56	Treatment 1	228	5
	Dai Phu	44	Treatment 1	156	4
	Phuong Dam	75	Control	241	35

5.1.4 Role of World Vision Vietnam

The project has been fortunate to have a strong relationship the NGO, World Vision Vietnam, since 2001. This included involvement in previous projects funded directly by ACIAR ("Facilitating farmer uptake of ACIAR project results: Component 4 - Rat control in rice-based farming systems" VN31-174945) and also an AusAID-funded Capacity-Building for Agriculture and Rural Development (CARD) project ("Enhancing capacity in rodent management in the Mekong delta region using non-chemical methods").

These activities were principally conducted in southern Vietnam in Binh Thuan, Tien Giang and Soc Trang provinces from 2001 to 2002, but the involvement of World Vision Vietnam was maintained in an informal capacity through links with other ACIAR rodent projects in Vietnam. Furthermore, one key staff member of World Vision Vietnam (Mr Tuan) successfully enrolled in MSc degree at James Cook University based in Townsville, Queensland, and was a recipient of a John Allwright Fellowship through ACIAR, linked to this project. He was awarded his MSc in 2009.

These projects led to the development of a rodent "manual" (“*Quản lý chuột hại lúa*”), which was the modification and translation of the rodent manual "Field methods for rodent studies in Asia and the Indo-Pacific" (Aplin et al., 2003; published by ACIAR). World Vision Vietnam played a key role in modifying this resource and translated into Vietnamese for local use by research staff and extension staff throughout the country.

As part of this project, World Vision Vietnam played a key role in examining the regional adoption pathways of EBRM. This was achieved through their Area Development Programs (ADP) in Ha Nam province and Hung Yen province, both in the Red River Delta, Vietnam. As such, CTBS were introduced in some areas through the ADPs, along with Community Action activities. Use and adoption of CTBS and Community Actions were monitored in a number of communities. Training activities were conducted with farming communities. World Vision Vietnam also monitored yield loss using exclusion plot methods (small areas of 2x2 m protected from rat damage by exclusion fencing compared to "open" 2x2 m plots).

5.2 Location of activities in Indonesia

5.2.1 Study location in Indonesia

This project was located in two of the key areas where lowland irrigated rice is grown and where rodents have been identified as a significant constraint. Rice is generally grown in two seasons each year, a wet season rice crop and an irrigated dry season rice crop. In some areas only one crop is possible, but in other areas, more than two crops per year are possible, depending on the varieties of rice grown and the availability of irrigation water to support the production.

West Java, Bali and South Sulawesi are the three most important rice growing areas of Indonesia, with West Java and South Sulawesi having significant rodent problems, thus these two regions were considered for this project (Figure 5.2). South Sulawesi has a production surplus of 1.2 - 1.5 million tonnes/year. These were typical intensive lowland irrigated rice cropping systems and were similar in nature to those that were intensively studied in the previous ACIAR rodent project (AS1/1998/036) in West Java (Singleton et al. 2005; Jacob et al. In Press), so the project team was reasonably confident that there was a reasonable chance of success. Furthermore, as in Vietnam, there were good extension networks and linkages with relevant institutions and a strong willingness to be involved in the project by farmers and local authorities, which was confirmed after initial visits by the project team through key informant interviews (KII) and focus group discussions (FGD).

Figure 5.2. Location of study sites in Karawang (West Java) and Pinrang District (South Sulawesi), Indonesia.

A representative district was chosen within West Java and South Sulawesi. Previous ACIAR funded research was conducted in Cilamaya regions, Subang District, West Java Province. A nearby district, Karawang District, was chosen in West Java so that it was reasonably independent from previous work, but with a similar farming system and opportunities for successful rodent management.

No work had been conducted in South Sulawesi, despite the desire for work on rodent management in this region when ACIAR-funded projects were being set up about 10 years previously. Pinrang District in South Sulawesi was chosen because of the relatively high levels of rodent damage that occurred there and the representative cropping system for that region. However, some small-scale testing of the CTBS was conducted in some Districts of South Sulawesi in 2004 because of the rodent problems that were being experienced. These were Bone, Soppeng, Wajo, and Pinrang Districts. Despite showing promising signs of effectiveness, there was little adoption and development until this project started up in 2006, so there was strong interest, particularly in Pinrang District.

5.2.2 Farming system and cropping calendars in Indonesia

South Sulawesi

In Pinrang, there are two main rice crop seasons, and some vegetable cropping (Table 5.5). The average yields of rice are [data still to add] kg/ha for the 1st rice crop and [data still to add] kg/ha for the 2nd rice crop.

Table 5.5. Cropping calendar for Pinrang District, South Sulawesi, Indonesia, showing planting (P) and harvesting (H) timings and when serious rodent damage occurs (***).

Crop	J	F	M	A	M	J	J	A	S	O	N	D
1st rice crop	P	→	H	H								P
2nd rice crop					P	P	→	H	H			
Vegetable										P	H	
Rat damage		***					***			***		

West Java

In Karawang, there are two main rice crop seasons, and some vegetable cropping (Table 5.6). The average yields of rice are 5-6.5 t/ha for the 1st and 2nd rice crops.

Table 5.6. Cropping calendar for Karawang District, West Java, Indonesia, showing planting (P) and harvesting (H) timings and when serious rodent damage occurs (***).

Crop	J	F	M	A	M	J	J	A	S	O	N	D
1st rice crop	H	H								P	P	→
2nd rice crop			P	P	→	H	H					
Vegetable								P	H			
Rat damage					***			***				***

5.2.3 Implementation of treatments in Indonesia

Given ongoing projects in ecological rodent management in West Java, it was decided to align the EBRM strategies in Indonesia as much as possible with these projects and with the Primatani program. We aligned with two important national agricultural programs. One was the Primatani program which promoted best agricultural practices and business models for farmers at the village level. The second was the implementation of Integrated Crop Management (ICM) through 60,000 Farmer Field Schools in 2009-2010. One of the ICM modules, written by Dr Sudarmaji and his team, was on EBRM. Both programs provided important vehicles for scaling out EBRM strategies from the district level to the provincial level in West Java as well as South Sulawesi.

In Indonesia, we focused on four main EBRM technologies: CTBS, synchronised cropping, coordinated community campaigns at key times and field hygiene. These were categorised into CTBS and Community Action, so we proposed the following treatments:

- *Treatment 1*: CTBS and Community Action demonstration site, thus establishing a CTBS in combination with synchronised cropping, coordinated community campaigns and field hygiene.
- *Treatment 2*: Community Action demonstration site, thus applying synchronised cropping, coordinated community campaigns and field hygiene only.

Treatments 1 and 2 were implemented simultaneously in all treatment villages in December 2006. Control villages did not receive any treatment, and farmers were free to continue their normal rodent management strategies.

In the first year of the project (2006), we worked with two treatment and two control villages in each region. Extension communication strategies included demonstration sites and farmer visits in the first round of treatments, and demonstration sites, farmer visits and mass communication techniques in the second round of treatments. Before implementation of the treatments, a baseline KAP&SE survey was conducted in the treatment and control villages (2007).

As in Vietnam, the distinction between "treatment" and "control" blurred with each successive season, as more farmers from control sites became interested in adopting the EBRM strategies that were being tested on the treatment sites. In the final year of the project, all sites were effectively considered as treatment sites, plus other surrounding sites (this will be explained more fully below in terms of diffusion of EBRM to other villages and districts, Section 7.3).

The original plan for allocation of treatments and stratification of households for implementation of the KAP&SE survey are shown below (Table 5.7 and Table 5.8).

Table 5.7. Treatment/control villages in Karawang district, West Java, Indonesia.

Village (name)	Farmer group (name)	Area (ha)	Type of site	Members (#)	Sample size
Citarik		*285*	*Primatani & ACIAR Treatment*	*185*	*60*
	Sri Maju I		Tr.1 in DS, Tr.2 in WS	52	17
	Sri Maju II		Tr.1 in DS, Tr.2 in WS	42	14
	Sri Mulya Sejati		Tr.1 in DS, Tr.2 in WS	50	16
	Sri Subur		Tr.1 in DS, Tr.2 in WS	41	13
Bojongsari		*393*	*ACIAR Treatment*	*266*	*60*
	Sri Mekar		Tr.1 in DS, Tr.2 in WS	71	16
	Sri Lungguh		Tr.1 in DS, Tr.2 in WS	64	14
	Sri Mukti		Tr.1 in DS, Tr.2 in WS	48	11
	Sri Subur		Tr.1 in DS, Tr.2 in WS	38	9
	Sri Gemah		Tr.1 in DS, Tr.2 in WS	45	10
Kertawaluya		*476*	*Control*	*546*	*60*
	Sri Asih		Control	45	5
	Sri Lugani		Control	75	8
	Sri Rahayu		Control	70	8
	Sri Jembar		Control	90	10
	Sri Rukun		Control	121	13
	Sri Mulya		Control	145	16

Table 5.8. Treatment/control villages in Pinrang district, South Sulawesi, Indonesia.

Village (name)	Farmer group (name)	Area (ha)	Type of site	Members (#)	Sample size
Leppengan		*1033*	*Primatani & ACIAR Treatment*	*380*	*75*
	Siparappe		Tr.1 in WS, Tr.2 in DS	96	19
	Sassang		Tr.1 in WS, Tr.2 in DS	68	13
	Massosorang I		Tr.1 in WS, Tr.2 in DS	87	17
	Massosorang II		Tr.1 in WS, Tr.2 in DS	60	12
	Cenrana		Tr.1 in WS, Tr.2 in DS	69	14
Salo		*917*	*ACIAR Treatment*	*685*	*75*
	Sipakaenre		Tr.1 in WS, Tr.2 in DS	79	9
	Sipatuo		Tr.1 in WS, Tr.2 in DS	76	8
	Boriangin		Tr.1 in WS, Tr.2 in DS	41	4
	Mamminasae		Tr.1 in WS, Tr.2 in DS	58	6
	Teppo I		Tr.1 in WS, Tr.2 in DS	81	9
	Teppo II		Tr.1 in WS, Tr.2 in DS	52	6
	Sipatokkong		Tr.1 in WS, Tr.2 in DS	72	8
	Baga		Tr.1 in WS, Tr.2 in DS	42	5
	Sipakainga III		Tr.1 in WS, Tr.2 in DS	55	6
	Bissu		Tr.1 in WS, Tr.2 in DS	75	8
	Aka		Tr.1 in WS, Tr.2 in DS	54	6
Bentengnge		*1114*	*Control*	*1404*	*75*
	Rahmat		Control	87	5
Marannu	Soraja		Control	102	5
	Massamaturue		Control	85	5
	Massamaturue II		Control	97	5
	Tosalamae		Control	72	4
	Tadang Palie I		Control	83	4
	Tadang Palie II		Control	85	5
	Sipakamase I		Control	63	3
	Sipakamase II		Control	88	5
	Teppo		Control	21	1
	Aserae		Control	75	4
	Belawae		Control	51	3
	Pammarse		Control	62	3
	Sipodeceng I		Control	70	4
	Maccolli Loloe		Control	35	2
	Sang hyang seri		Control	50	3
	Reso Pammase		Control	69	4
	Mattunru-tunrue		Control	87	5
	Pallaworumae		Control	85	5
	Sipakainge		Control	27	1

5.3 Methods and activities conducted

The main activities conducted during the project follow.

5.3.1 Training and evaluation of impact of implementation of EBRM by farmers on damage and yields

Training in EBRM

Training courses were developed and run early in the project and were delivered to key project support staff and extension staff in each of the project locations. The aims of these workshops were:

- To introduce staff to the basic aspects of rodent biology and taxonomy;
- To provide theoretical and practical experience in identifying rodents and assessing their breeding biology;
- To become aware of some of the key rodent management strategies for the project and to identify rodent damage to rice crops; and
- To develop the skills of the staff so that they can teach other staff and to teach farmers about rodent management ("training-of-trainer", TOT).

In Vietnam, the structure for the plant protection network is shown in Figure 5.3. There are also a range of institutional linkages across separate institutions/agencies to facilitate the uptake of EBRM technologies across Vietnam. A similar approach was used in Indonesia.

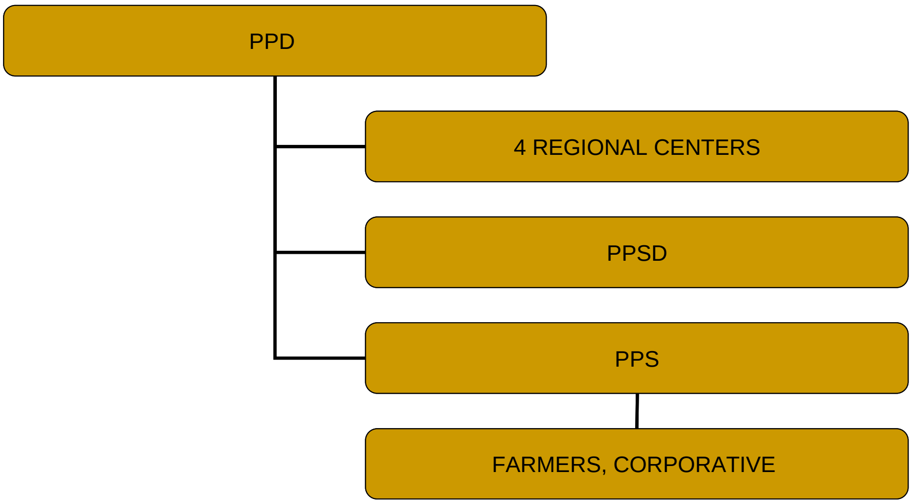

Figure 5.3. Extension network for plant protection in Vietnam. The Plant Protection Department (PPD) is the chief agency, which develops training packages and materials, which are then distributed and filtered down through the 4 regional centres, the Plant Protection Sub-Departments (PPSD) to the Plant Protection Stations (PPS) within each province, and ultimately to farmers.

The training course was specifically designed for staff of agencies affiliated with the project, including Plant Protection staff, World Vision staff, provincial extension staff working in Ha Nam and An Giang (Vietnam) and West Java and South Sulawesi (Indonesia). Other staff from neighbouring provinces were welcome to participate. There was a mixture of theory (PowerPoint slides) and practical sessions. The topics covered in the course included:

- Biology of rodents;

- Population ecology of rodents;
- Taxonomy of rodents;
- Experimental design;
- How to build a CTBS (video presentation) and practical session in field;
- Assessment of rodent damage to crops; and
- Management practices for rats.

Fifteen to twenty people attended each course. In Vietnam, the first course was held in Ha Nam 16-18 April 2007 and the second course was held in An Giang 23-25 April 2007. In Indonesia, courses were held in 2007. In Vietnam, participants received a copy of the World Vision book: "*Quản lý chuột hại lúa*". In Indonesia, participants received a draft version of the Indonesian "rodent manual". They also received a Vietnamese or Indonesian version of the PowerPoint presentations.

Assessment of damage and crop yields

Some basic protocols were available for in-country staff to collect basic data on assessing rodent damage to crops and for assessing rice crop yields. Some of these were standardised methodologies designed through earlier ACIAR rodent projects and published in April et al. (2003), while others followed standard techniques for assessing the area of fresh rodent damage, as described in Brown and My Phung (In Press). Where possible, data collected were collected and summarised.

5.3.2 Knowledge, attitudes and practices, and social-economic survey (KAP&SE survey)

The KAP&SE survey served as the basis for much of the quantitative data used to evaluate the project. The KAP&SE survey was administered to farmers in each project location prior to the implementation of EBRM strategies in the first year of the project (2006; pre-implementation KAP&SE survey), then repeated near the end of the project to examine the influence of EBRM interventions (2008/09; post-implementation KAP&SE survey). The post-implementation survey was largely the same as the pre-implementation survey, but some repetitious questions were omitted and additional questions were added to better understand the changes over time.

In June 2006, project partners in-country were provided training on how to conduct interviews with farmers. The questionnaire and process was pre-tested and modified accordingly. The training enabled the enumerators to become familiar with the questionnaire and to ensure they were collecting the correct information. In Vietnam, a refresher training course was run prior to administration of the post-implementation survey to remind the enumerators about survey technique and to re-familiarise themselves with the survey.

After the surveys were completed with the farmers, a second training session was conducted on how to enter the data into databases, how to verify the data and check for errors.

The KAP&SE questionnaire contained detailed questions related to performance indicators (eg crop damage, yield loss, rat abundance, and plastic and rodenticide use) as well as detailed questions related to farm household characteristics, knowledge, attitudes and practices. Based on expert knowledge and local expert feedback in combination with experience from field testing, the final version of the KAP&SE survey was developed (see Appendix 1). The KAP&SE questionnaire comprised the following components:

1. *Background information*: Summary farm household information related to location, family size and memberships.

2. *Socio-economic and demographic information*: Detailed information regarding farm household family members living within as well as outside the hamlet.
3. *Farm household characteristics and cropping pattern*: Summary information regarding farm household resource availability, cropping pattern, product disposal and sources of financial capital for the season 2005-2006, and detailed information regarding labour and input use for the latest cropping season.
4. *Rodent and other crop pests*: Summary information regarding insect and animal pests the farm household has experienced over recent years.
5. *Knowledge on rodent pest management*: Summary information regarding the farm household's experience in rodent management.
6. *Farmers' attitudes and beliefs towards rats and rat management*: Information regarding the farm household's opinion and beliefs about rats in general and rat management in particular.
7. *Rat management practices*: Information regarding farm household's source, type and timing of applied rat control methods in irrigated rice production.
8. *Collective action and cooperation*: Summary information regarding the farm household's involvement in community activities over the last year.
9. *Sociability, social cohesion and in*clusion: Summary information regarding the farm household's relationships and degree of interaction with community members.
10. *Information and communication*: Summary information regarding the farm household's source of information used in production and marketing.

Note that the KAP&SE questionnaires differed slightly between provinces, to pick-up on fundamental differences in local bio-physical and socio-economic circumstances.

Each KAP&SE interview took about 2 hours, i.e. equivalent to a maximum of three interviews per day by the one interviewer. Given a sample size of 240 and 280 in An Giang and Ha Nam province respectively, this equates to over 80 and 95 person days to conduct the full KAP&SE survey.

5.3.3 Diffusion of EBRM (Vietnam)

To assess the spread of EBRM strategies, both secondary data and primary data were collected from all the other districts of Ha Nam province and two nearby provinces, namely Nam Dinh and Hung Yen. The diffusion study was only done in Ha Nam province due to financial constraints. Hung Yen was chosen because the trap-barrier system was set up there, and was promoted and supported by World Vision Vietnam. Nam Dinh was chosen because this is the largest rice province near to Ha Nam.

Secondary data, which included rice production and marketing, socio-economic and demographic characteristics were gathered from the General Statistics Office (GSO) and from the respective commune statistics units.

Primary data on rice production and rodent management practices at farm level were collected through a farm household survey in September 2009. Eleven communes were surveyed, of which six communes were located in Ha Nam but were non-project sites for the rodent management project. Respondents were selected randomly in the communes. The total number of households interviewed was 413; with 253 respondents from Ha Nam, 74 from Nam Dinh, and 86 from Hung Yen (Table 5.9).

Table 5.9. Sample size distribution for the diffusion study that was conducted in the Red River Delta, Vietnam, in 2009, to assess the uptake of EBRM by farmers.

Province	Number of communes	Total number of respondents	%
Ha Nam	6	253	61.0
Nam Dinh	2	74	18.2
Hung Yen	3	86	20.8
Total	**11**	**413**	**100.0**

Focus group discussions and key informant interviews were likewise conducted. Also, key people in the agricultural cooperatives within the surveyed communes were interviewed using a semi-structured questionnaire. These people included the chairman of the respective agricultural cooperatives and the leader of the rat control group (if it existed in a commune). The information collected included qualitative descriptions of rat management activities conducted by the agricultural cooperatives and the rat control groups, and their attitudes towards rodent management. A total of ten leaders of agricultural cooperatives and ten persons from rat control groups in ten communes were interviewed.

5.3.4 Governance and institutional arrangements for EBRM (Indonesia)

Key Informant Interviews (KII) were conducted to gather qualitative data on the relationship between the extension system and the rice farming communities and to ascertain the progress of extension of EBRM to farmers.

A total of 114 key informant interviews were undertaken in mid 2007 (West Java) and early 2008 (South Sulawesi) and repeated in early 2009 (in both West Java and South Sulawesi) (Tables 5.10 and 5.11). Interviews were conducted with the civic and government organisations involved in rodent management at both sites as advised by the Indonesian project partners of ICRR in West Java and BPTP in South Sulawesi. A project member from ICRR interpreted for the CSIRO researchers. The village-based interviews were conducted with community leaders, village/local government leaders, irrigation managers, credit managers (Gapoktan), farmer group leaders and individual farmers.

Table 5.10. Summary of number of interviewees for Key Informant Interviews (KII) for Round one interviews (2007) and Round two interviews (2009) in West Java.

Agency/Village	Interviewee Role	2007	2009
Dinas	Manager, pest/disease monitor, extension coordinator & officer	4	-
BPTP	Researcher and extensionist	2	2
Head of subdistrict		-	1
ICRR	Researcher	-	2
UPBD	Agency head, Primatani & village extension officers	-	5
Citarik	Village leader	1	1
	Sub-village leader	1	-
	Credit manager (Gapoktan)	1	1
	Irrigation manager	1	-
	Farmer group leaders	4	2
Kertawalya (control)	Village leader	1	1
	Sub-village leader	1	-
	Credit manager (Gapoktan)	Position empty	1
	Irrigation manager	1	-
	Farmer group leaders	6	1
Bjongsari	Village leader	1	1
	Sub-village leader	1	-
	Credit manager (Gapoktan)	Position empty	1
	Irrigation manager	1	-
	Farmer group leaders	3	2
	Sub Total	*29*	*22*
	Total	**51**	

Table 5.11. Summary of number of interviewees for Key Informant Interviews (KII) for Round one interviews (2008) and Round two interviews (2009) in South Sulawesi.

Agency/Village	Interviewee Role	2008	2009
Dinas	Director & officer pest management/plant protection	2	4
IPPHPTPH	Director	1	
PIPP	Director, director planning, administration officer	3	
PPP	4 extensionists covering 3 villages	4	
BPTP	Research and extensionist	-	2
Primatani	Project officer	-	1
BPPP Extension Agency	Head, 6 officers	-	7
Military	Officer assigned to village security	-	1
Marannu (control)	Village leader	1	1
	Community leader	1	1
	Credit manager (Gopokta)	1	-
	Irrigation manager	1	-
	Farmer group leaders/members	3	2
Salo	Village leader	1	2
	Community leader	-	-
	Credit manager (Gopokta)	1	1
	Irrigation manager	1	-
	Farmer group leaders/members	4	3
Leppangang	Village leader	1	1
	Community leader	1	-
	Credit manager (Gopokta)	1	1
	Irrigation manager	1	-
	Farmer group leaders/members	2	3
Leading farmers	From the villages of Matungtua and Leppangang	-	2
	Sub Total	*30*	*33*
	Total	**63**	

5.3.5 Overview of modelling

A range of models were developed to better understand important biophysical, social and economic issues surrounding rodent management (and the complex interactions between these issues) for farmers in lowland irrigated rice cropping systems in Indonesia and Vietnam. Data for these models have come from a range of sources, but a key data source was the pre-implementation KAP&SE survey in Vietnam. These are part of the pathways assessment approach that was described above. There are overlaps and interactions between the integrative model, economic model, rodent population model, rat damage model and rice crop model (Figure 5.4).

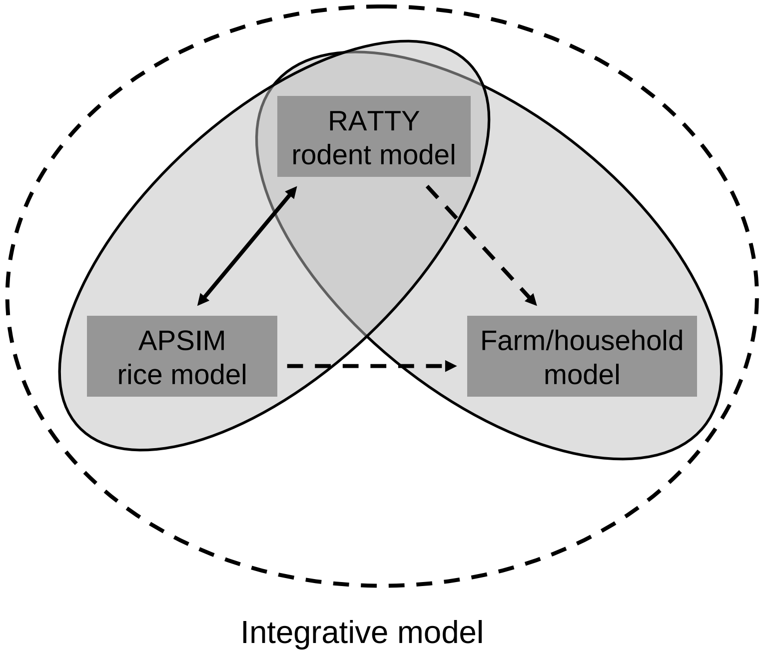

Figure 5.4. Relationship between separate modelling components to demonstrate the links between each component.

5.3.6 Integrative modelling

The purpose of the integrative modelling was to combine simplified descriptions from the other modelling techniques to provide a systems-level overview of how different social, economic and ecological components interacted to drive the success of rat control strategies. This 'overview' perspective was employed, via visual participatory modelling techniques (Bousquet et al. 1999), to communicate the effectiveness of different rat control techniques to government employees, extension officers and farmers on the ground in An Giang and Ha Nam in Vietnam, and South Sulawesi in Indonesia. In addition, the approach provided a proof-of-principle example of the potential benefits of integrative modelling to quantitative analysis of different rat management strategies in Southeast Asia.

An advanced agent-based model (ABM) of rice growth, rat damage, rat population dynamics, and rodent control activities was created based on information provided by other parts of the project. The integrative model was constructed in a modular manner for each component of the system: rice growth and economics; rat population dynamics; rat damage; rodent control actions (both impacts on rodent population and household economics). This enabled users to generate an approximate model early in the project that could be updated to incorporate the best information available as other parts of the project provided new insights, as well as to enable fine-tuning of parameters to the different conditions observed in the different case studies.

The rice growth part of the model captured sowing and harvesting dates, variability in these dates and rice growth rates informed by the rice crop modelling component of the project. The goal was not to describe the minutiae of the rice crop model, but to capture the important aspects of the broad behaviour of this component of the system. A logistic growth model (Lotka, 1925) was coupled to sowing and harvesting practices, based on reasonable initial estimates of the number of rice growing seasons, sowing and harvesting dates and rice growth rates. Because synchronicity of planting is known to affect rat population dynamics (Singleton et al. 2003; Sudarmaji et al. In Press), both the average sowing and harvesting date and the variability across the community between sowing and harvesting dates were described.

The model was constructed such that it could easily be updated with site-specific variability for any of these parameters. Harvest rates were affected by sowing/harvesting dates, rice growth rates, and the amount of damaged incurred throughout the growing season by rodents. Household and community economic profit for each field was then tied to the net rice productivity. Within the model, these economic resources were used to support families, invest in new rice-growing capital for the following season, and fund rat control activities, as described below.

The rat population model was based on simple predator-prey dynamics (Lotka 1925, Volterra 1926) coupled with a spatial movement component for the rat 'predator'. The details of the interactions were designed to be informed by the "Ratty" rodent population modelling component of the project. Rats consumed rice to gain nutrient 'energy', then used some of that energy to move around the landscape to find new food sources. If they moved but did not find food, they eventually ran out of energy and died. If and when they achieved a sufficient surplus of nutrient-energy they reproduced.

Because the actions of each rat 'agent' were pre-programmed in this manner, fallow periods where rice fields were bare of food naturally and automatically led to movement of rats into the bund and horticultural crop areas and significant die-off amongst the rat population, both characteristics observed in field studies (Jacob et al. In Press), without any need to define these characteristics explicitly within the model code. Thresholds for nutrient intake leading to reproduction were set to produce observed birth patterns throughout the season - specifically, in both the model and the real world large-scale population growth is not generally observed until close to harvest when rice fields provide sufficient food sources to support reproduction (Brown et al. 2005, Jacob et al In Press).

At each time step of the model, rats consumed what rice they could at their current location, then moved around the landscape in the direction of the best 'nearby' source of food. The amount of energy gained by each rat was determined by the quality of the patch at which they ate, and the damage to the rice was proportional to the amount eaten by rats. Abundant rice was considered more desirable to rats than alternative horticultural crops, so when the rice fields started to mature, rats automatically moved back from horticultural plots into the fields. By these means, the rodent population dynamics were linked to rice production sub-models, and inversely, rice productivity was linked to damage due to the total population of rats and the way they moved around the landscape. In particular, non-synchronous cropping led to clear increases in the fallow-period rat population and total rat damage during growing season, as seen in field studies (Singleton et al. 2003).

Multiple rodent control activities were captured in the model: rat hunting, trapping, linear and Community Trap Barrier Systems. Because, like synchronous sowing, synchronous control is known to be important to community rat control endeavours (Brown et al. 2006, Jacob et al. 2010, Sudarmaji et al. In press), the timing of these activities could also be controlled by the model. Each rodent control technique involved a certain time commitment, a certain financial commitment, and experienced a certain rate of success. Rat hunting, for instance, involved a large time commitment from a farmer, with relatively little economic cost. The farmer moved around the landscape, and if they found a rat, they killed it. Trapping, on the other hand, involved less time but more money (for the trap), and relied on the rat agents being attracted to the food in the trap once they approached close to its location.

Of special note was the construction within the model of the Community Trap Barrier System (CTBS). Within the model, the CTBS was simply constructed of its component parts - an early sowing schedule (adjustable - approximately 3 weeks before main sowing), surrounded by a fence that rats could only pass through in certain locations, and traps at those locations. The CTBS worked in the model just like it does in the real world - just before the end of the fallow when the CTBS field is planted, rats searching the landscape for food drift randomly towards the field in preference to horticultural crops and the surrounding fallow land. When they reach the fence, they randomly search around it for an entry - when they find it, they enter the field and are caught in the trap. All of this occurs automatically based on the simple search-and-consume rules for the rat agents in the model and the normal growth model for rice with an early trap field sowing date, without any specific CTBS code required in the model.

The net economic benefit of different strategies, and different combinations of strategies, was estimated by assigning a per-kilogram price to rice and multiplying it by the harvest for each field, minus the cost of materials (seed etc.) associated with sowing the rice, and the cost of materials required for rat control actions, information provided by the household economic modelling component of the project. In this manner, for instance, the net economic benefit of a process like trapping can be calculated for a farmer operating on his own. However, much more complex strategies can be assessed: the net economic benefit to the community of a certain level of trapping amongst different farmers can be calculated if every farmer operates independently (random or asynchronous), but the same calculation can also be performed if everyone puts their traps out at the same time (synchronous).

More importantly, the net benefit of truly community-level strategies like CTBS can be assessed - the large cost of establishing a trap field, fencing it and providing traps and labour to run it can be offset against the gain to the entire community of reduced rat populations throughout the growing season. Because we provided an integrative systems-level model, therefore, this approach got to the core of the issue with ecologically based rodent management - that it is a systems-level management strategy - and moreover, it did it in a manner that could be easily visually communicated to non-science personnel, across language boundaries, as discussed in Section 7.5.1.

5.3.7 Economic Modelling

A framework for assessing the economic impacts of integrated rodent management strategies has been constructed. Among others, rodent pests directly affect farmers' financial returns by: damaging crop growth, incurring post-harvest losses as well as damaging buildings and capital. Rodents have the greatest impact on the poorer communities, as they lack the capacity to absorb seasonal losses. Additionally there are episodic losses associated with rodent population outbreaks due to climatic conditions. Rodent management requires trade-offs to be made at both individual and community levels, e.g. between transaction costs (negotiating, co-operating), operational costs (allocation of labour and material) and the benefits of increased productivity (reduced rodent damage).

To determine the most cost-effective rodent management strategies, costs (labour, material) and benefits (due to decreased crop damage) were analysed for various levels of community participation and various levels of control. Data used for the model was obtained from various sources including: a production system simulation model (APSIM), benefit-cost analyses (BCA) and farm typology based on the KAP&SE survey. Various rodent management strategies were investigated including, no-control (NC), community trap-barrier system (CTBS) and Community Actions (CA). An economic sensitivity analysis was undertaken to determine which parameters were most likely to have the greatest impact on farmers' rodent control decisions. This was undertaken by changing key parameters by 10% to estimate the net effect on farm income.

Farm typology

Based on a (statistical) cluster analysis performed in the statistical program R (http://www.r-project.org/) two farm type clusters were identified. Total farm area was identified as the primary driver for the farm type clusters, which in turn affected total rice production, rice yields per hectare, and total farm income.

Benefit-cost analysis

A benefit-cost analysis (BCA) was undertaken for the various methods of rodent control. Data used for the model was based on the KAP&SE survey in combination with expert consultation and validation. For this analysis a cost function (including fixed and variable input costs) was derived for the two farming clusters. To determine the gross benefit an APSIM model (see Section 5.3.10) was used to identify rice productivity responses to rodent control. The benefit of each rodent control strategy for each farm type cluster was estimated as the difference in total farm income with and without the using the different methods of control, less the cost of control. The BCA was undertaken for each harvesting season as well as on an annual basis.

The BCA was used also to investigate the effects of rodent control efficacies (with kill rates between 10% and 100%) and control dedication (with participation rates between 10% and 100%) to investigate the effects of 'free riders' within the community. Results are presented in Section 7.5.2.

5.3.8 Rodent population modelling

A simple rodent population model was constructed in Excel to better understand how a rodent population might respond to a range of rodent control strategies. The model was designed to capture some of the key population dynamics and characteristics that were observed with a free living population in a lowland irrigated rice cropping system. The model (*Ratty*) was constructed utilising monthly live-capture data from the 4-year population study conducted in Vinh Phuc Province in the Red River Delta (Brown et al. 2005) as part of ACIAR project AS1/1998/036.

Rates of increase from observed population data were used to incorporate a range of demographic parameters (eg breeding, deaths, immigration and emigration) without the need to model each component individually.

These data from Vinh Phuc province were considered the best available data set of rodent populations for the region. Although there were two rice crop growing seasons in Vinh Phuc, then the winter vegetable crop growing season, it was still relatively similar to the observed population dynamics of rodent in An Giang province (My Phung and P. Brown personal observations). This was further supported by data from the An Giang Plant Protection Department which conduct weekly assessments of fresh rodent damage to rice crops throughout the year, described in the following section. The observed damage from rats is similar in nature to what is expected given the potential rodent population dynamics that were modelled here.

Once the basic monthly rates of increase were calculated, the model was adapted so that it was possible to reduce rodent populations at any point in time and look at the response in the population and take into account potential compensation of the rodent population, as observed in various field studies of rats in Vietnam and Indonesia (Brown and Tuan 2005, Brown et al. 2005; Singleton et al. 1998). This control and recovery function was designed and implemented to replicate the observed response of rodent populations to implementation of individual control actions. This was reflected through slightly higher rates of increase. The compensatory effect was designed to dampen over a short period of time, as is observed in free-living rodent populations that recover after control has been applied.

Ratty was designed so that individual control actions could be applied to the population and the relative response in population recovery could be observed. Individual control actions could be applied, or multiple actions could be applied at different crop stages. The types of control actions that could be represented in the model included use of rodenticides, intensive trapping efforts, community campaigns, but also sustained activities such as the CTBS which are set 3 weeks prior to the planting of the main rice crops through to 3 weeks prior to harvest. This is important because it allows flexibility in the timing and effectiveness of rodent control strategies applied to the population. This utility was then a functional feature of the model when it was incorporated into the APSIM rice crop model described below.

Once the model output matched field experience, the monthly time-step model was converted into a daily time-step model population model.

5.3.9 Rat damage modelling

The purpose of this work was to increase the understanding of the nature and dynamics of rodent damage to rice crops. In Vietnam, the Plant Protection Department (PPD) of An Giang Province routinely collected information on damage to rice crops for a range of pest species and diseases (brown plant hopper, rodents, rice blast etc.). Experienced field staff collected this information every week from each of the 11 Districts in An Giang province over a five year period. The rodent species found in these lowland irrigated cropping systems are principally the rice field rat (*Rattus argentiventer*), the lesser rice field rat (*R. losea*) and the black rat (*R. rattus*) (My Phung unpublished data). These data on the nature and dynamics of rodent damage to irrigated rice crops were subsequently incorporated into economic models and rice crop simulation models of rat damage and the resulting yield loss caused by rodents and to explore the benefits of controlling rodents at different crop stages and to determine cost-effectiveness of different management strategies.

From July 2004 through until November 2008, PPD staff accumulated records of fresh damage throughout all weeks that the crops were grown, and recorded whether damage was low, high or if there was complete loss. PPD staff also estimated the level of overall damage/yield loss each week (percentage damage). Data were collected for five DX1 crops (dry season rice crop), five HT2 crops (1st wet season rice crop) and five Vu3 crops (2nd wet season rice crop). The data were analysed and a general description of the nature and dynamics of rodent damage to rice crops was formulated. These data are in the process of being published (Brown & My Phung In Press).

5.3.10 Rice crop modelling

A rice crop model was built within the APSIM modelling framework (Agricultural Production systems SIMulator) to model the response of rice crops to rodent damage and to look at the effect of rodent control on increases in rice yields. The APSIM rice model gave the ability to explore any range or combination of control actions, different levels of effectiveness and a range of timing of application to explore the most appropriate timing and level of control required to achieve a positive benefit in terms of increased rice yields. We followed a similar approach to that which was used to develop an APSIM wheat crop model to look at the benefit of controlling mouse populations in wheat crops in Australia (Brown 2007; Brown et al. 2007). There were significant parallels in these systems and also significant learning to be gained from the Australian context that meant the development of the model was reasonably straightforward.

Significant work was required to make the rice crop model operational within the APSIM modelling framework. Colleagues from CSIRO (Don Gaydon) and IRRI (Tao Li) have been working to incorporate the ORYZA2000 rice crop model (developed by IRRI and Wageningen University, Netherlands) into the more functional ASPIM modelling framework. In particular, Don Gaydon provided the basic code that was necessary to allow the model to run, and provided input into how the rodent damage functions could be incorporated within the rice crop model.

Once a basic version of APSIM rice was available, it was characterised for the An Giang rice cropping system. This was achieved by collecting basic farming information from five typical rice farmers in An Giang. Data collected included rice yields from the previous 10 years, soil type, planting rules (dates for planting and planting rates), fertiliser application rates, residue management, weeding control and other basic farming information.

A range of daily environmental and climatic information was also required to allow APSIM to run effectively. This included daily rainfall (mm), minimum and maximum temperatures (°C), solar radiation (mj/m^2) and evaporation (mm). Some of these data were available from the An Giang Metrological Office (as monthly averages), but solar radiation data were not available - this is an important issue for modelling rice crops, because their growth is sunlight dependent. The An Giang Metrological Office collected the number of sunshine hours per day, so this had to be converted into solar radiation. Fortunately within APSIM there is solar radiation data from Los Baños in the Philippines (a similar latitude to An Giang), so this was adapted to match the sunlight hours for An Giang.

The information gained from farmers and the climate data (met file) was generally sufficient to benchmark APSIM yields with farmers' yields.

To validate the APSIM model, data from a clipping experiment that was conducted by My Phung as part of her PhD (My Phung et al. In Press) was run through APSIM to check that the rodent damage effects observed on the rice crops led to the desired impact in terms of yield reductions.

Once the basic APSIM model was functional, a rat damage function was written. All the calculations for the damage function were written and coded in Excel, so that a block of text was copied from Excel and pasted into APSIM, then the APSIM model could be run. The damage function was created from the damage data observed in An Giang, described in Section 7.5.5. It was decided to run the model over a single year which captured the dynamics of the three rice crops (DX1, HT2 and Vu3), but with damage data averaged over the five years that data were available from the An Giang Plant Protection Department (see Section 7.5.5 for details). Output from the APSIM model was collected and summarised.

5.4 Project strategy

The overall strategy of the project was to build up activities on the ground in the first year or so and establish some demonstration sites and gather baseline information, then to build and expand activities over subsequent years going from a village to district to a regional/provincial level.

Year 2006-2007: District level focus:

- Project sites/villages of about 1000 ha
- Establish village / district base-line situation
- Develop predictive approach that allows for the assessment of most (cost-) effective pathways for enhancing the adoption of EBRM strategies
- Work closely together with government agencies, NGOs and farmers to identify, assess and implement adoption pathways
- Evaluate effectiveness of implemented adoption pathways

Year 2008-2009: Regional / provincial level focus:

- Establish provincial / regional base-line situation
- Assess most (cost-) effective pathways for enhancing the adoption of EBRM strategies using the earlier developed predictive approach
- Work closely together with government agencies, NGOs and farmers to identify, assess and implement adoption pathways
- Evaluate effectiveness of implemented adoption pathways

5.5 Personnel involved in the work

A key focus of the project was on extension of ecologically-based rodent management to farmers. As such the main institutions in both Vietnam (Plant Protection Department) and Indonesia (ICRR and AIAT South Sulawesi) had a strong extension focus. World Vision Vietnam also joined the project to further test extension approaches (particularly the diffusion and adoption of ecologically-based rodent management) through their Area Development Program in neighbouring provinces in the Red River Delta.

Within CSIRO, the project was initially led by Dr Peter Roebeling, who had specialist experience in resource economics and was strongly interested in the adoption of the ecologically-based rodent management for farmers in Vietnam and Indonesia. This reflected a ground shift in project leadership from the previously-run CSIRO projects funded by ACIAR with a strong rodent ecology thrust. There was significant input also from Dr Grant Singleton and Dr Flor Palis (IRRI). Unfortunately, Dr Roebeling took a position in a University in Portugal after two years with the project, so Dr Peter Brown took over the Project Leadership. Social researcher Emma Jakku also left the project after two years.

In 2008, Dr Cameron Fletcher joined the project as an integrative modeller, Mr Martijn van Grieken as a resource economist and Ms Monica van Wensveen as a project coordinator. Dr Toni Darbas was working nearly throughout the project as the CSIRO sociologist on the project. This gave the CSIRO team a mix of different skills and disciplines, which added to the modelling work that was conducted over the final two years of the project.

The key staff throughout the project are listed in Table 5.12. Other significant staff changes throughout the project were:

2006

- Mr Huan (deputy director PPD – project leader Vietnam) appointed his assistant Mr Tung to take care of the day-to-day project activities.
- Mr Tuan (project leader World Vision Vietnam) received a John Allwright Fellowship for a 2 year MSc study at James Cook University. The new project leader at World Vision Vietnam was Mr Dzung.
- Ms My Phung (project leader PPSD-South) received a John Allwright Fellowship for a 3 year PhD study at the University of Queensland. The new PPSD-South project leader was Mr An.
- Dr Nugraha (project leader Indonesia) retired as director of AIAT. The new project leader was Dr Muhrizal.
- Mr Muslimin (project staff member at AIAT-South Sulawesi) received a scholarship for a 3 year PhD study at Bogor University. The new project staff member was Mr Sunanto (AIAT).

2008

- Mr Tung starting a John Allwright Fellowship to undertake a PhD at the Australian National University in Canberra starting in July 2008. He was replaced by Mr Loc who will look after the day-to-day project activities in Vietnam.
- New project leader at An Giang PPSD was Mr Sy Lam.
- Mr Nguyen Phu Tuan left NIPP. A replacement staff member to be linked to this project was still to be negotiated.

- Various changes to personnel at CSIRO Sustainable Ecosystems have taken place. These were outlined in a letter sent to ACIAR on 19 March 2008. Dr Peter Roebeling (Project Leader) resigned from CSIRO in December 2007. In January 2008, Dr Peter Brown (10% CSIRO, 10% ACIAR funded) become the new Project Leader. Other new staff include Ms Monica van Wensveen (15% ACIAR funded), Mr Martijn van Grieken (10% CSIRO, 20% ACIAR funded) and Dr Cameron Fletcher (15% ACIAR funded).

2009

- There was no replacement staff for Mr Tuan who left the National Institute for Plant Protection in Hanoi.
- Mrs Que Quach Thi replaced Mr Dung from World Vision Vietnam. Mrs Que is the National Coordinator – Agriculture, Program Quality & Development Department, World Vision Viet Nam.
- Ms Nunung (Nur ’Aini Herawati) left ICRR to undertake a PhD at Gadja Mada University, Yogjakarta (“Sterility control of rice field rats” co-supervised by Dr Sudarmaji, ICRR and Dr Lyn Hinds, CSIRO).

Table 5.12. Staff involved in project and key roles/skills.

Country	Institution	Name	Skill
Australia	CSIRO Sustainable Ecosystems	Dr Peter Roebeling	Project Leader (2006-2007), Resource Economist
		Dr Peter Brown	Project Leader (2008-2010), Rodent Ecologist
		Dr Cameron Fletcher	Integrative Modelling (2008-2010)
		Dr Toni Darbas	Sociologist
		Dr Emma Jakku	Sociologist (2006-2007)
		Mr Martijn van Grieken	Resource Economist (2008-2010)
		Ms Monica van Wensveen	Project Support (2008-2010)
Philippines	International Rice Research Institute	Dr Grant Singleton	Rodent Ecologist
		Dr Flor Palis	Anthropologist
Vietnam	Plant Protection Department	Dr Nguyen Huu Huan	Project Leader
		Ms Vo Thi Quynh Nga	Project Officer
		Mr Tran Thanh Tung	Project Officer, the John Allwright Fellowship student (PhD)
		Ms Nguyen Thi My Phung	Extension Staff, then John Allwright Fellowship student (PhD)
	National Institute for Plant Protection	Dr Nguyen Phu Tuan	Rodent Ecologist
	Southern Regional Plant Protection Department	Mr Ho Van Chien	Extension Staff
	Institute for Agricultural Sciences	Mr La Pham Lan	Project Researcher
	Plant Protection sub-Department Ha Nam Province (red Ricer Delta)	Dr Bach Quoc Huy	Project Leader Ha Nam
		Various	Extension staff
	Plant Protection Department An Giang Province	Mr Sy Lam	Project Leader An Giang
		Various	Extension staff
	World Vision Vietnam	Mr Le Anh Tuan	Coordinator, then John Allwright Fellowship student (MSc)
		Mrs Quach Thi Que	Coordinator, World Vision
Indonesia	Indonesian Center for Agriculture Technology Assessment and Development	Dr Murizal Sarwani	Project Leader Indonesia
		Dr Erizal Jamal	Project Support
	Indonesian Centre for Rice Research, West Java	Dr Hasil Sembiring	Director, Project Support
		Dr Sudarmaji	Rodent Ecologist
		Mr Agus	Rodent Ecologist, Extension
		Ms Nur A Herawati	Rodent Ecologist then PhD
	Extension Agency, West Java	Various	Extension staff
	Assessment Institute for Agricultural Technology, South Sulawesi	Dr Djafar Baco	Project Leader South Sulawesi
		Drs Nasruddin Razak	Senior researcher
		Mr Ramlan	Field staff
	Extension Agency, South Sulawesi	Various	Extension staff

6 Achievements against activities and outputs/milestones

Objective 1: To work with farmer communities that face severe rodent impacts, to develop incentives that enhance cohesive community participation in integrated ecologically-based rodent management (EBRM) with at least 70% farmer participation.

no.	activity	outputs/ milestones	completion date	comments
1.1	Develop baseline profile of 4 villages in districts for adoption and diffusion of EBRM. Impacts on farmers at household and community level will be measured and assessed against set targets, using both qualitative and quantitative performance indicators.	Interviews of key farmers conducted and field sites selected KAP surveys completed Socio-economic profile of villages completed Performance indicators defined and targets set	Dec 2006	This activity was completed in the first year of the project. Data from the KAP surveys were used to explore social and economic aspects of rodent management, particularly related to farmer management decisions and to compare different rodent management scenarios. Information was also gained through the Key Informant Interviews and Focus Group Discussions. A post-implementation KAP survey was conducted in 2009 and some data were available for analysis to look at adoption and diffusion of EBRM. A diffusion study was conducted in Ha Nam, Vietnam.
1.2	Develop EBRM demonstration villages for foci for spread of rodent management technology.	EBRM actions agreed upon and farmers begin their actions TBS established – 1 per 10-12 ha at experimental sites	Dec 2006 Completed March 2010	*Vietnam – An Giang*: treatment & reference sites established in 2006. Treatment 1 (CTBS) & Treatment 2 (CA). 16 CTBS were established in Tri Ton and Tinh Bien districts in Summer-Autumn season 2008. CA increased from 1 to 4 campaigns per district in the Winter-Spring 2008-2009. *Vietnam – Ha Nam*: The prime focus was implementation of CA. Rodent management activities have increased from 15 communes to 152 communes across the whole province. Some CTBS have been set up. *Indonesia – South Sulawesi*: Marannu was converted from a control site to a treatment site in Oct 08. Activities were conducted on all 3 sites, focus on using L-TBS in combination with CA (nets, synchrony cropping, mass campaigns). CTBS was not needed (damage was low). *Indonesia – West Java*: In the first planting season of 2009, 10 villages in the Tirtamulya Sub-District of Karawang implemented EBRM activities through assistance & supervision of trained extension staff.

1.3	Record on and off-farm inputs and outputs of agricultural and non agricultural economic activities incorporating farmer diaries to measure changes in practices and economic costs and benefits at the farm household level.	Farmer dairies filled-in once a week Yield data collected at all experimental and untreated sites	Completed March 2010	Rudimentary data from farmer diaries were collected in each treatment and each reference site. Where possible, five male and 5 female farmers were chosen to fill-out a farmer diary card every two weeks. Much of the data was unable to be analysed, so the KAP&SE data was used where possible. Data on yield were also collected at the end of each crop season. Yield loss data from enclosure plots were collected, but not from all sites.

PC = partner country, A = Australia

Objective 2: To build on experiences from previous projects to develop a functional institutional framework for project implementation at national, provincial and district levels and maintain effective communication across all agencies.

no.	activity	outputs/ milestones	completion date	comments
2.1	Establish efficient and functional institutional linkages that facilitate access to and delivery of technology to communities of farmers. In Indonesia advisory and technical steering groups will be established.	Indonesia: Steering committee established, meets twice a year and are informed of important project developments; Vietnam: all institutions fully informed of key developments	Established in 2006 Completed March 2010	*Vietnam*: Communication between PPD-North (Ms. Nga, Mr. Dzung, & Mr Huy), PPD-South (Mr Sy Lam), IAS (Mr. Lan), World Vision (Mrs Que) & provincial governments is effectively managed by the deputy director of PPD (Dr Huan – project leader Vietnam). Communication with local government is effectively managed by the sub-PPD project leaders (Mr Sy Lam & Dr Huy). *Indonesia*: Steering Committee normally met at least once a year, but there were many opportunistic meetings of key project staff to monitor the progress of the project (every 1-2 months). Overall coordination was very effective.
2.2	Effective communication achieved through annual coordination meetings, regular contact with key staff and farmer groups, and promotion of EBRM through media, brochures and farmer group (eg farmer field schools, IPM clubs)	Annual workshops held with strong end-user participation & high in-country profile	Indonesia – August 2007 Vietnam – April 2008 Completed March 2010.	*Vietnam*: Annual planning workshops were held each year and also as part of Review (May 2009). There was strong & effective participation. There were field visits & discussions with farmers. Communication of the project has been maintained by distributing pamphlets, t-shirts and caps. Local television covered EBRM in Ha Nam. Strong link with the national "*3-reductions & 3-gains*" initiative. *Indonesia*: Annual planning workshop were held each year and also as part of the Review (May 2009). There was strong involvement of key farmers, extensionists & AIAT staff from S Sulawesi & W Java. There were field visits which strengthened partnerships & supported the promotion of EBRM. EBRM was integrated into ICM FFS and Primatani initiatives. *CSIRO & IRRI*: Staff attended planning workshops, training courses, ran focus group discussions & key informant interviews. Contact maintained by email. CSIRO hold regular project meetings & phone conferences. Flor Palis (IRRI) and Toni Darbas (CSIRO) did Focus Group Discussions together in Vietnam to compare methodologies and cross-country issues between Vietnam and Indonesia.

		High level of adoption of project outputs by poor farmers. Adoption of project outputs by governments. Indonesia: outputs adopted in national Integrated Crop Management strategy for rice. Vietnam: outputs feed into national best practice for rice	Completed march 2010	Adoption of Community Actions was measured in Ha Nam, Vietnam. There was also strong evidence for successful adoption of Community Actions in An Giang (Vietnam) and in West Java and South Sulawesi (Indonesia). Diffusion of EBRM occurred in neighbouring districts and provinces as a result of the communication plan and training activities. The mainstreaming of EBRM into National training modules occurred in Vietnam ("3-reduction & 3-gains") and Indonesia (Primatani and the ICM FFS). The level of adoption of EBRM was assessed in ha Nam province as a case study. The effect of EBRM on livelihoods was assessed through the post implementation KAP&SE survey but not all data were available for a rigorous analysis. The governance and institutional arrangements for adoption were examined in Indonesia (West Java and South Sulawesi) through Key Informant Interviews and Focus Group Discussions.

PC = partner country, A = Australia

Objective 3: Develop and implement effective incentive and communication strategies and establish active linkages with local and national government to mobilise mass community actions against rats for strategic intervention, where the timing of actions will be based on the rodent ecology of the specific regions.

no.	activity	outputs/ milestones	completion date	comments
3.1	Incorporate EBRM into regional extension networks at the provincial level. Develop and implement incentive schemes and communication strategies through active linkages with existing (in-) formal institutions, local and national government. Mobilise community campaigns against rats for strategic intervention where timing of these campaigns will be based on the rodent ecology of the specific regions.	Incentive and communication strategy implemented Mass campaigns for community rodent management successfully organised	Commenced July 2007 Completed March 2010 Completed March 2010	EBRM was incorporated within regional extension networks (Vietnam "*3-reductions, 3-gains*"; Indonesia: Primatani, ICM, IP Padi 400 & P2BN). Training of regional extension staff has occurred & new villages & districts have implemented EBRM strategies through the assistance of trained extension staff & support from the project. In 2008 thousands of farmers were involved in mass campaigns, but captures of rats were much lower than in previous years because of effective management. In line with EBRM principles, management was applied early, with higher yields as a result. In An Giang, Vietnam, there were 111 CA conducted across the 3 seasons, with 8,216 farmers participating and 9,055 rats caught all 11 Districts. IRRI took video footage to support rodent management. 500 t-shirts, 1000 caps, 500 books, 1000 notebooks & pens were distributed to FFS participants. In Ha Nam, there were 32 CA campaigns, with 16 extra outside project sites and 1 by local authority. There were 2,880 farmers involved. There were 5 training course run involving 150 farmers. Training was incorporated in the IPM FFS for diffusion of knowledge (68 FFS involving 2,350 farmers). Key informant interviews have been used to understand the governance arrangements for agricultural extension, institutional, financial & cultural barriers to extension, & to evaluate the effectiveness of the technologies & extension strategies to date. This also examined adoption of EBRM being promoted by the project.
3.2	Assess the economic, social and environmental impacts of EBRM at the community and regional level.	Assessed economic, social environ-mental impacts of EBRM at experimental sites	Completed March 2010	Economic, social & environmental impacts of EBRM at the community & regional have been analysed. IRRI played a strong role in training country staff & assisting with cleaning & validation of socioeconomic data. CSIRO developed socio-economic models and has run different scenarios of the models to examine household decision making associated with adoption of rodent management activities.

3.3	Measure the rate of diffusion of the technology at a district and regional level, and determine whether farming communities are likely to sustain their use of these technologies. This analysis will differentiate for types of farm households and villages, in order to assess the variability in adoption behaviour amongst farmers and villages.	Measured diffusion of technology at provincial level & spill-over benefits to other regions	Completed March 2010	The rate of diffusion of EBRM was assessed in Ha Nam, Vietnam through an IRRI study (with the University of Hanoi). It was not possible to repeat the study in other regions because of the lack of resources. In Indonesia & Vietnam, focus group discussions (IRRI/CSIRO) in all sites have monitored adoption of EBRM. New communities are implementing EBRM. In Vietnam, the successful implementation of rodent management strategies (particularly CA) is attributed to the joint effort of many institutions & their staff, leaders & farmers. Follow-up key informant interviews were conducted to understand the institutional, financial & cultural barriers to extension & to evaluate the effectiveness of the technologies & extension strategies to date.

Objective 4: To further develop extension materials and train NARES and NGO partners in rodent biology, EBRM and methodologies to facilitate adoption of technologies.

no.	activity	outputs/ milestones	completion date	comments
4.1	Based on a general handbook for Asia and Pacific published in 2003, develop handbooks in Indonesian and Vietnamese on rodent biology and management for NARES and NGO partners. Develop curriculum for train the trainers (key farmers, provincial AIAT staff (Indonesia) and sub PPD staff (Vietnam), NGO staff) and requisite brochures to support extension activities at the community and regional level.	Training and technical material available in local language for local trainers.	August 2006 Completed March 2010	The Vietnamese handbook was completed and additional copies were printed, brochures were developed and training curriculum was developed and implemented. In Indonesia, the technical manual was at final draft form. Training was mainstreamed into the "3-reduction, 3-gains" program in the Mekong River Delta. WVV has incorporated it into their Area Development Programs. In Indonesia, training was coordinated with AIAT along with farmers, extension staff and local government staff in the “EBRM scaling out” program. Training of EBRM was integrated into national programs (Primatani, ICM, IP Padi 400 & P2BN). A range of technical materials have been successfully used in both Vietnam and Indonesia.
4.2	Involve NGOs (World Vision Vietnam; various in Indonesia) to assist with the regional adoption of pathways of EBRM.	NGOs have knowledge & training resources to apply community based EBRM to other regions	Completed 2010	NGOs have been involved in regional adoption pathways, particularly through the Area Development Programs of World Vision Vietnam. It was possible to engage NGOs in Indonesia. There was a short gap in linking activities with WVV, but a new staff member has successfully integrated activities which led to significant adoption of EBRM in the ADPs.

7 Key results and discussion

To effectively promote EBRM practices and for farmers to sustainably benefit from them, it is necessary to understand 1) how farmers make decisions about rodent management and 2) the context surrounding those decisions.

To this end, the project teams worked on a range of complementary activities:

- KAP&SE surveys provided social and cultural context around decision making for rodent control, and provided valuable economic data for the models.
- The diffusion study in Vietnam looked at pathways and vehicles used to communicate EBRM to farmers and evaluated their effectiveness.
- The study on institutional arrangements in Indonesia uncovered key constraining and enabling factors for the uptake and maintenance of EBRM, at the policy and governance level.
- Economic modelling looked at the economic benefits of different control methods at household and community levels, using an optimisation strategy for farm management
- Rodent population modelling, rodent damage modelling and rice crop modelling together provided new insight into biophysical aspects of rodent control, particularly questions of how rodent populations respond to control, what impact rat damage has on crop yield and what strategy and level of control is needed to achieve desired yield increases.
- Integrative modelling provided a virtual tool to examine the interacting social, economic and ecological components of a farm system and to test the viability and efficacy of various control strategies.

Together these components provide a necessary theoretical assessment and understanding of how rodent populations interact with rice crops and how different rodent control strategies can change damage to crops to influence rice crop yield. Together with survey data on economics of rice farming from the KAP&SE survey, an economic assessment of benefits to managing rodents using a range of strategies including Community Actions and CTBS on farmer income. This modelling is conducted to better understand some of the subtle relationships between the separate components, but also to validate some of the observed changed on field sites to better understand the mechanisms that allowed EBRM to be successful. This means that it is possible to examine closely some of the individual mechanisms that influence increased profit in isolation and to undertake sensitivity analyses to determine the robustness of the EBRM strategies.

First, it is important to provide evidence of the activities that have been conducted in terms of training and activities conducted by farmers and then the influence of these on farmer yields damage by rodents to crops. These are the ultimate consequence of implementing EBRM. Some of this information will be repeated in Section 8 (Impacts), however, since this is a project about implementation and adoption, this information is also considered as "results", and so they are presented here as context for the other results sections.

7.1 Farmer training, involvement and results of damage and yields

7.1.1 Number of farmers involved/participation rates and activities undertaken by farmers (CA & CTBS)

A key focus of the project was to encourage farmers in Vietnam and Indonesia to implement EBRM strategies. This was achieved through "training-of-trainer" (TOT) courses for research support staff and extension staff, who in turn conducted training courses with farmers and acted as general project support for the farming communities. Key farmers also played a role in sustaining EBRM activities within project sites.

Vietnam

In Vietnam, there were 174 staff trained throughout the project (PPSD, PPS and local technicians). The number of farmers trained in EBRM strategies steadily increased through each successive year as training courses were run for farmers, and as the activities covered by the project spread from the core project sites to neighbouring villages and districts. The total number of farmers trained was 7,051. Over the course of the project, there were 100 CTBS set up, there were 218 community activities conducted with more than 17,000 farmers involved.

Ha Nam:

- Activities started in four cooperatives in 2006, and expanded to 15 cooperatives by 2008. This increased to 152 cooperatives in the final 12 months of the project (2009). By the end of the project, the number of farmers that were trained and participated in Community Actions was more than 3,500.
- There were a range of training, extension and communication activities conducted. There were 104 CA campaigns, including 16 outside project sites and one by a local authority, with a total of 8,300 farmers involved. There were five training course run involving 150 farmers.
- Training was incorporated in the IPM FFS for diffusion of knowledge (169 FFS involving 6,474 farmers).

An Giang

- EBRM was originally implemented in two Districts (2006), but was being implemented in all 11 Districts of An Giang by 2009.
- There were 111 CA conducted across the 3 seasons, with 8,216 farmers participating and 9,055 rats caught all 11 Districts.
- In An Giang province, there was an increase in the number of Community Actions undertaken by farmers from 1 to 4 campaigns per district in the Winter-Spring season 2008/2009.
- The local government has provided up to 1 Billion Dong. Also there is a strong link with the “3 reductions, 3 gains” program in Mekong Delta.

In Vietnam there were more than 17,000 farmers trained in EBRM over the course of the project. While the number of farmers seems impressive, the actions taken by farmers and the benefit of conducting EBRM is more important. For example, there is evidence that (see later sections for details):

1. The number of farmers using rodenticides has been dramatically reduced;
2. The area and severity of rodent damage to rice crops has steadily been reducing over the course of the project; and
3. The number of farmers involved in Community Actions has been increasing.

A significant factor for the training and participation of farmers in An Giang province in the Mekong Delta has been through the training to farmers of the "3-reductions, 3-gains" program. As of 2009 there is about 85% of rice areas where "3 reductions, 3 gains" has been adopted in An Giang in particular, and about 40% of total rice area in the Mekong Delta River in general. As part of this broad training program, a specific training module on EBRM was included. This had broad applicability across the Mekong River Delta, not just An Giang province, so was likely to reach thousands of farmers. The strength of this approach was that it embedded the core principles of EBRM into a broad management approach for rice cropping employing the reduced input and increased output model that the "3-reductions, 3-gains" approach uses. This approach also demonstrates how rodent management can be mainstreamed into other broadly relevant management of rice crops.

Through the course of the project there were more than 11,000 leaflets distributed, 1,500 CTBS guidebooks, 500 t-shirts, 2,000 caps, 500 books, 1000 notebooks & pens distributed to FFS participants and other farmers. It is recognised that these, by them selves, are unlikely to have a significant affect on the decisions by farmers to implement EBRM, they can help strengthen the EBRM message, especially when used in combination with training courses, demonstration sites, and other extension activities.

A further addition to formal training and technical material has been the dissemination activities conducted by PPD staff (See Section 8.4 for more details). This includes:

- National and provincial TV, covered ecologically based rodent management through the local and national program on rodent management (VTV1,2,3; Ha Nam TV, AGTV);
- Produced and distributed VCD on how to make EBRM at commune level to farmers' clubs, farmers' Association (Ha Nam); and
- Interactive dialogue on in local TV (An Giang and Ha Nam TV).

Vietnam - World Vision Vietnam

Seven CTBS were piloted in La Son commune, Binh Luc District of Ha Nam province, and in Kim Dong and Phu Cu ADP of Hung Yen province. This was done to overcome some of the perceived constraints of using the CTBS, where a small field is required to be planted 14-21 days prior to the surrounding area, which is difficult in terms of availability of labour, water and seed at the time. For this reason, a range of initiatives for the modification of the CTBS were trialled, like planting varieties of short duration and highly attractive to rodents, and also applying fertiliser at optimum times to shorten the growing duration for the summer rice crop in Ha Nam, and Hung Yen.

In addition, Community Actions to control rodents were organised in the areas surrounding the CTBSs installed in Binh Luc District, as well as in four other Communes of four other Districts, namely Ly Nhan, Thanh Liem, Kim Bang, and Duy Tien. Community Actions were conducted four times, at land preparation, maximum tillering stage, panicle initiation stage, and flowering stage, and involved digging rat holes and pumping with water, hunting with dogs and installing wire rat traps.

Indonesia

As in Vietnam, the number of farmers trained in EBRM strategies steadily increased through each successive year as training courses were run for farmers, and as the activities covered by the project spread from the core project sites to neighbouring villages and districts.

West Java

- There was an increase in the number of villages involved in scaling out activities in Karawang District from 3 villages (in 2006), to 10 villages (in 2009). These villages covered a total of 12,670 households and 43,085 people. In West Java, of the villages that implemented rodent management activities in the wet season of 2008, 4 villages (Karang Jaya, Karang Sinom, Kamurang & Tamansari) implemented EBRM activities with minimal assistance and supervision from trained extension staff.
- 2007 wet season: 19,603 rats were captured during Community Action in 6 villages involving 3,704 farmers.
- 2008 dry season: 20,710 rats were captured during Community Action in 10 villages involving 5,719 farmers.
- A range of training and extension activities were conducted and included radio programs by ICRR staff and extensionists, TV shows, >10,000 visitors to ICRR, 5000 leaflets and booklets disseminated at training events, newspapers and website, field assistance to other provinces for rodent control programs linked to national programs (Primatani and P2BN; an integrated crop management approach), and assistance for providing LTBS/CTBS materials to other provinces.
- In West Java in 2009, all 10 villages in the Titramulya Sub-District of Karawang implemented EBRM activities through the assistance and supervision of trained extension staff.
- In 2007, two training courses were run on "Rodent management in irrigated lowland rice" at the local government office in Citarik with The extensions, ICRR, IAAT. There were 35 farmers & local government staff at the first training, and 40 farmers & local government staff at the second training.
- In 2008, training for villages outside core project areas commenced. In Karawang District, this included ICRR, IAAT, Dinas Pertanian, who were running the training sessions. There were 40 participants which attended, made up of representatives from two farmer groups (Gapoktan), extension officers, researchers and representative of house wife from Citarik village.

South Sulawesi

- In South Sulawesi, the "control" village was converted to a treatment village in October 2008, with EBRM activities being conducted on all three sites, focussing on LTBS in combination with Community Actions (nets, synchronous cropping, mass community campaigns). CTBS was not used in the final year because Community Actions were sufficient to keep losses by rodents to a minimum.
- In South Sulawesi, there was strong focus on the training of extension workers through formal training courses but also through informal discussions with extension staff. 2000 leaflets were distributed and a video of rodent management was developed and produced. Demonstration sites were created and used as a focus for training and capacity building among farmers from different areas, which included formal field days and through cross visits, with farmers from Takalar, Sidrap, Enrekang, Polman (West Sulawesi Province) and individual farmer from other districts.
- TOT activities were conducted with extension staff from 3 villages and 1 from Sidrap, and 1 from Southeast Sulawesi. It also included 3 PPD staff from South Sulawesi and 1 from Southeast Sulawesi. Three from BPTP South Sulawesi and one from Southeast Sulawesi. One key farmer from each of the three villages and one from Southeast Sulawesi attended.

- Farmer training was conducted initially in December 2006 over a 2-day period. There were 30 farmers from Salo, 30 farmers from Leppangan. The course was structured around a session on theory in the evenings and practical sessions during the morning.
- Extension worker training was achieved through specific training courses that were run in December 2008 for 30 extension workers. The course was conducted at the BPP office in Teppo and was linked with the Primatani program at Leppangan. Furthermore, at every meeting of agriculture extension staff, the management of rats must be discussed as part of the agenda of the meeting.

National level

At the national level, ICRR delivered a range of training activities, many of which were outside ICRR and West Java. These training activities came about because of the need for rodent management information from other provinces and to build capacity in other districts and provinces severely affected by rodents. The training courses were run in the following areas by ICRR staff:

- South Sulawesi (2008)
- South-East Sulawesi (2008)
- South Sumatera (2008)
- Bengkulu (2008)
- Central Java (2008)
- Central Kalimantan (2007)
- West Sumatera (2006)
- West Java (2007-2008)

Part of the training program in ICRR has involved the integration and implementation of rodent management into a range of national-level programs including:

- ICM field school,
- P2BN,
- Primatani,
- IPM training.

There have also been a range of farmer groups, researchers from provincial (AIAT), extension (Dinas), and local government institutions. This included a series of demonstration plots including CTBS fields with early trap crops and LTBS set in different habitats. The demonstrations also included field demonstrations of fumigation and digging burrows during land preparation, and Community Actions (“Kalagumarang”).

ICRR have a dedicated rodent laboratory ("Tikus laboratorium") located at Sukamandi[1]. This is where much of the theory of rodent management is done with groups of farmers and extension staff. They also have a wide range of technical information to supplement the hands-on displays, including posters, leaflets, miniature model of the CTBS, multiple live traps, fumigators, pictures of rodent controlling techniques etc.

A further addition to formal training and technical material has been the dissemination activities conducted by ICRR staff. This includes:

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[1] *The Rodent Laboratory at ICRR was initially developed with assistance from ACIAR in 1995 as part of the initial ACIAR-funded projects in Indonesia. It is still being used today and is widely recognised as the main research and extension facility for rodent management in Indonesia.*

- Interviews with Dr. Sudarmaji from ICRR, covered ecologically based rodent management through the local radio program on rodent management (Legeg Sunda Gaya Menak, 106 FM);
- Launch of special live radio program in March 2007; and
- Interactive dialogue on in national TV (TPI & Metro TV).

ICRR has designed several activities (eg. research activities, open house, displaying techniques of rice cultivation and pest-diseases control, rice week, etc) to disseminate agricultural technologies to farmers, extension workers, students, decision makers, etc. (Table 7.1). In general, more than 75% of visitors to ICRR were interested in to visit rodent laboratory & its activities.

Table 7.1. Number of visitors to different training activities conducted at ICRR from 2005 to 2008.

No	Activities	2005	2006	2007	2008
1.	Seminar & Scientific meeting	34	37	129	140
2.	Field trip	1364	1763	3511	414
3.	Workshop	60	120	380	149
4.	Technical assistance & comparative study	100	150	680	75
5.	Training	20	75	310	20
6.	Short training	23	50	42	30
7.	National Rice Week	-	-	-	35000
8.	Others	50	120	60	92
	Total	**1651**	**2315**	**5712**	**35920**

There were close to 20-30,000 of farmers trained in EBRM over the course of the project. Again, there is good evidence to show that this training has led to change in the behaviour and decisions taken by farmers with respect to how they manage their rodent problem (see following sections). These include:

1. Reduction in the number of farmers using rodenticides;
2. Reduction in the use of sump oil mixed with endosulfan (a toxic mixture for rats and other animals in the rice fields);
3. The area and severity of rodent damage to rice crops has steadily been reducing over the course of the project; and
4. The number of farmers involved in Community Actions has been increasing.

Thousands involved in mass campaigns, but captures of rats lower because of the effective management conducted earlier.

In Indonesia, the rodent management activities were closely aligned with the Primatani, program which has led to the sustainable implementation of EBRM. A range of other programs were also targeted to ensure a wider exposure of EBRM by farmers in different areas. These programs included ICM, IP Padi 400 & P2BN. It is difficult to estimate the number of farmers exposed to EBRM approaches through these approached and programs. However, the proof of the success of this approach is the reduced level of damage that has been observed, particularly in West Java and South Sulawesi over the last few years (see next section).

7.1.2 Changes in rat damage to crops and rice crop yield

Vietnam - General

The key result and impact of EBRM for farmers was yield increases of 0.9% to 1.9%. Furthermore, the overall level of rat damage reduced from 7-16% during 2001 to 2005 (prior to the implementation of the project), to less than 4% (some years less than 1%) after the project was implemented in 2006. This means greater rice yields and greater economic returns for farmers.

- In Ha Nam Province, There was a reduction in level of rat damage: from 7-16% from 2001 to 2005, to < 4% since 2006 (some years less than 1%). This translates into a reduction of 88% (Table 7.2) and an economic benefit of 100,000 - 500,000 Dong/ha increase in profit.

Table 7.2. Area of rodent infestation in Ha Nam Province, Red River Delta, 2001-2009. Project activities commenced in 2006. There was an 88% reduction in the average area affected by rodents from 9.6% (2001-2005) to 1.1% (2006-2009).

Year	Rice area (ha)	Affected area (ha)	Affected percentage (%)
2001	75,213	11,947	15.9
2002	76,107	7,956	10.5
2003	74,315	5,680	7.6
2004	73,318	4,975	6.9
2005	72,165	4,894	6.9
2006	71,006	2,786	3.9
2007	70,706	199.6	0.3
2008	68,440	186.4	0.3
Spring 2009	34,282	17.7	0.05

- In Ha Nam Province, the use of rodenticide significantly reduced from 230-990 kg/year (up to 2005) to 92-144 kg/year from 2006-2009. This is a reduction of 62-90%.
- In Ha Nam Province, the total area where EBRM activities were conducted covered an area of 1,278 ha of rice fields and brought an economic benefit of 255 million VND for the local communities.
- A community fund was established and the local government was contributing to rodent management.
- Some areas were still experiencing some rodent damage. An exclusion plot technique was trialled in Tri Ton and Tinh Bien Districts, An Giang Province in 2008 and demonstrated that yield losses were in the order of 4.3-8.6% without rodent management (Table 7.3).

Table 7.3. Difference in yield of plots inside rodent proof exclosures (protected from rat damage) and outside exclosures (prone to rodent damage) in five fields in Tri Ton and Tinh Bien Districts, An Giang Province, Vietnam, 2008.

District	Location	Field 1	Field 2	Field 3	Field 4	Field 5	Average
Tri Tôn	Outside	1.9	1.8	1.9	2.0	1.7	1.9
	Inside	1.8	1.7	1.5	1.9	1.6	1.7
	Difference (%)	*4.7*	*5.6*	*20.2*	*5.6*	*7.0*	*8.6*
Tịnh Biên	Outside	2.2	2.3	2.4	2.4	2.4	2.3
	Inside	2.2	2.2	2.2	2.3	2.0	2.2
	Difference (%)	*1.8*	*4.3*	*8.3*	*8.3*	*4.8*	*4.3*

- In An Giang Province, yield loss was significantly reduced from 4-8% (in 2006) to 2-4% (in 2009) (Table 7.4).

Table 7.4. Yield loss from five fields in Tri Ton and Tinh Bien Districts of An Giang Province, Vietnam in the DX1 2007/08 and HT 2008 seasons

District	Season	Field 1	Field 2	Field 3	Field 4	Field 5	Average
Tri Tôn	DX1 2007/08	4.7	5.6	20.2	5.6	7.0	**8.6**
	HT2 2008	2.9	5.3	6.3	0.0	5.6	**4.0**
Tịnh Biên	ĐX1 2007/08	1.8	4.3	8.3	8.3	4.8	**4.3**
	HT2 2008	5.3	2.5	3.8	0.0	1.9	**2.7**

- Overall there was a reduction in the area damaged and therefore yield losses across all of Vietnam (Figure 7.1). There was a steady decline in area damaged from 2001.

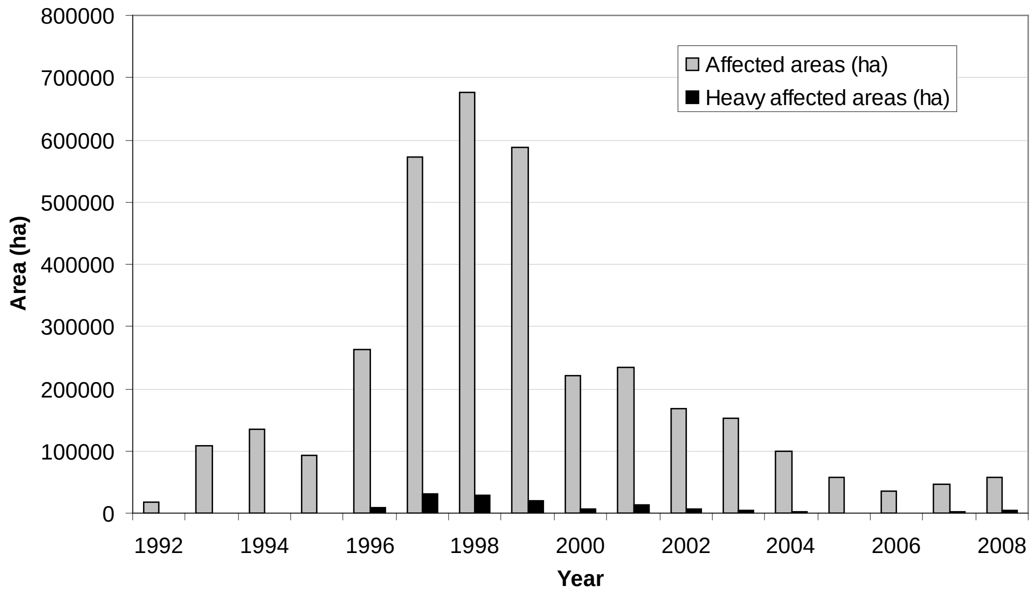


Figure 7.1. Infestation of rats in rice crops throughout Vietnam, 1992-2008. Shown is total area affected (>10% yield loss) and the areas identified as severely affected by rodents (up to 100% crop losses attributed to rodents) (Source: Plant Protection Department annual reports).

Vietnam - World Vision Vietnam

From the seven CTBS that were established, there were a total of 1,016 rodents captured, ranging from 93 to 317 per CTBS for the summer rice crop. The Community Actions yielded 2,944 rats (Table 7.5). The collective action to control rodents was taken 4 times for whole rice crop with participation of 60 farmers. The farmers used cleaned around the edge of the rice field, dug rodent burrows and filled them with water, and set wire rodent traps. The 20 collective actions organised by farmers in five communes of five districts in four times of rice crop killed almost 3,000 rodents. Community Actions for rodent control was effective because they reduced the density of the rodent population during the later stage of rice crop stage from flowering stage onwards.

Table 7.5. Number of rodents killed during Community Actions in 5 Districts of Ha Nam Province, Summer crop 2010, conducted by World Vision Vietnam.

Timing of Action	Digging burrows and pouring water in burrows	Hunting by dogs	Installing wire rat traps	Total rodents killed
Land preparation	695	47	343	1,085
Tillering stage	548	22	83	1,353
Panicle initiation stage	143	15	219	377
Flowering stage	57	6	66	129
Total	**1,443**	**90**	**1,411**	**2,944**

In Ha Nam, where CTBS were set up, there was a 0.3% yield increase compared to "reference" areas where normal rodent practices were undertaken, this is a relatively small increase. In areas where CTBS and Community Actions were applied, there was a 2.9% yield increase compared to "reference" areas. This is higher increase, and would be significant for a poor farmer.

In communes where CTBS and Community Actions were installed, the total input costs were 1,000,666 VND/ha, whereas in the other 4 communes where Community Actions were applied the total input costs were 442,500 to 570,000 VND/ha. In the "reference" areas without CTBS or Community Actions, but where farmers continued their normal rodent control methods, the total input cost was 174,000 to 417,800 VND/ha. This input cost was much lower than that in areas where CTBS were applied: by around 114,167 – 326,700 VND/ha. However, the areas where CTBS and Community Actions were applied, the rodent damage was less, resulting in increasing total income from 285,000 to1,000,000 VND/ha. The efficiency of using CTBS and Community Actions to control rodent was calculated at benefit of 170,883 to 599,000 VND/ha.

In Red River Delta, it was possible to use attractive aromatic, and short duration varieties of rice in combination with an earlier application of fertiliser. This overcame some of the perceived constraints raised by farmers in this area. Furthermore, the Community Actions for rodent control showed advantage like decreasing rodent population in rice fields as well as reducing the application and use of rodenticides in the field.

The efficiency of using CTBS and Community Actions to control rodents was higher than the "reference" areas by 170,800 to 599,000 VND/ha, therefore positively contributing to increased food security of farmers. This is a critical issue in the areas where World Vision Vietnam operates because of the food security issues these communities face.

The benefits of the CTBS and Community Actions includes improved social effectiveness because of the exposure to collective actions which mobilise the community’s participation. Furthermore, the decreased use of poison baits in the field improves the environmental benefits in the rice field.

However, the disadvantages of this approach include:

- Large area of rice fields needed for the CTBS and the high participation rate of the farming community: at least of some hundred farmers are required to mobilise the participation of community, in term of labour, rice field of CTBS, input for CTBS if without support of outside;
- In some areas facing drought conditions and sloped terrain, CTBS seems difficult to apply; and
- Some provinces such as Hung Yen, CTBS is not supported by the provincial government, so there is no supportive guidelines or instructions.

Indonesia

In Citarik and Bojongsari (West Java), there was a 5% increase in yields on treatment sites that implemented EBRM compared to other nearby sites that were conducting conventional rodent management practices (Figure 7.2). Rat damage was less than 10% (typical year damage is around 15%) with an average yield of 5.5 tonnes/ha in the second planting season of 2007 (average usually around 5 t/ha).

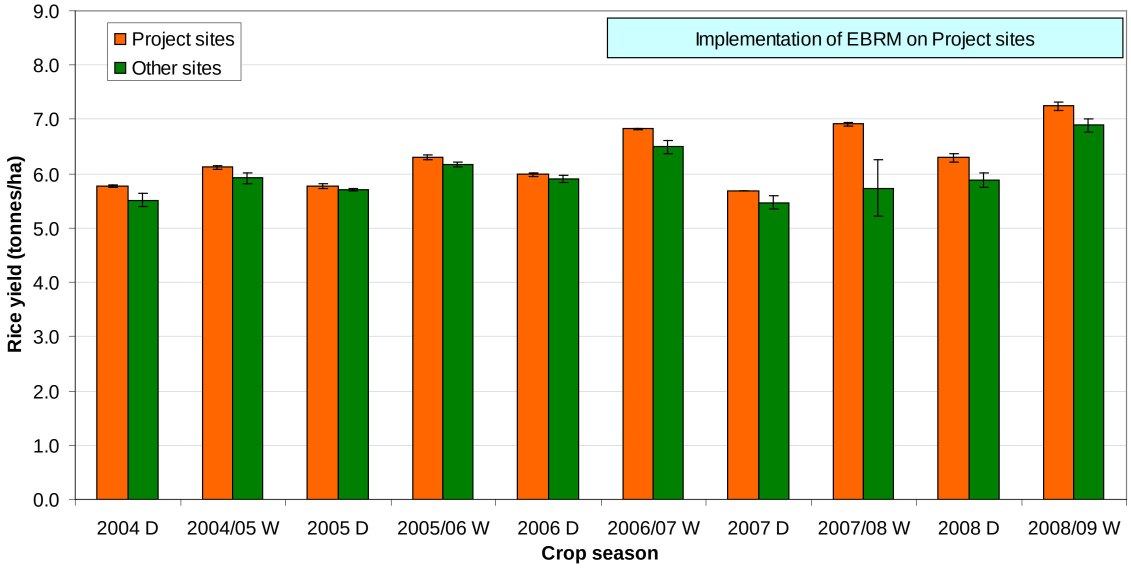


Figure 7.2. Mean yields of rice (tonnes/ha) from core project sites (n = 3) and other sites (n = 7) from before the project on ecologically-based rodent management (EBRM) and after implementation of EBRM in 2006 at Karawang District, West Java. There was a comparative increase of yield by 5% after implementation of EBRM on project sites compared to other sites after taking into account differences in yield prior to implementation. D = dry season rice crop; W = wet season rice crop.

A range of Community Action activities and CTBS were applied in each year in a range of locations/habitats, eg in the dry season of 2007 (Table 7.6), the wet season of 2007 (Table 7.7), and wet season 2008 (Table 7.8).

Table 7.6. Rat control activities by farmers in Citarik and Bojongsari during the 2007 dry season.

Site	Dates	Control Methods	Locations	No. rats captured
Bojongsari	12 Mar 07	Community action (flooding, digging rat burrows and sanitation)	Mango farm close to village	720
	23 Mar 07	Community action (fumigation, digging rat burrows, sanitation)	Along the irrigation channel bank	254
	30 Mar 07	Community action (fumigation, digging rat burrows, sanitation)	Along large bank by the road bank	75
	24 Apr 07	CTBS	Close to residential area	3
	24 Apr 07	CTBS	Close to the road	8
	27 Apr 07	LTBS	Along large bank by the road bank	14
	27 Apr 07	LTBS	Irrigation channel bank	21
Citarik	27 Apr-28 Jun 07	CTBS	Paddy field	8
	27 Apr-11 Jul 07	CTBS	Close to residential area	9
	28 Apr-28 Jun 07	LTBS	Big dike in the middle of paddy field	11

Table 7.7. Rodent control activities in villages in West Java, wet season 2007. The range in the number of participants in the different Community Actions is shown in brackets.

Village	Frequency of activity (Oct-Dec)	No. Rats captured	Total number of farmers involved per village
Citarik	10+	4,147	803 (45-155)
Bojongsari	8	3,073	1,374 (121-235)
Kertawaluya	8	3,594	Not monitored
Parakan	9	3,012	Not monitored
Cipondoh	7	3,415	946 (65-200)
Parakan Mulya	9	2,362	581 (40-102)
Total		**19,603**	**3,704**

Table 7.8. Rodent control activities in West Java villages, Dry Season 2008

Village	Frequency of activity (Mar-Apr 2008)	Total rats captured	Number & estimation of farmers involved/activity
Citarik	8	3,284	774 (55-200)
Bojongsari	8	2,638	559 (55-105)
Kertwaluya	8	1,940	438 (45-68)
Parakan	8	2,493	510 (51-83)
Cipondoh	8	2,860	574 (59-81)
Parakan Mulya	8	2,621	538 (60-78)
Karang Jaya	8	3,012	601 (60-89)
Karang Sinom	8	2,412	441 (42-82)
Kamurang	8	2,849	550 (59-90)
Tirtasari	8	3,612	734 (30-79)
Total		**20,710**	**5,719**

Indeed, the overall area of rodent damage has declined since the late 1990s, principally due to the involvement and impact of this (ADP/2003/060) and the previous ACIAR-funded rodent project (AS1/1998/036) (Figure 7.3).

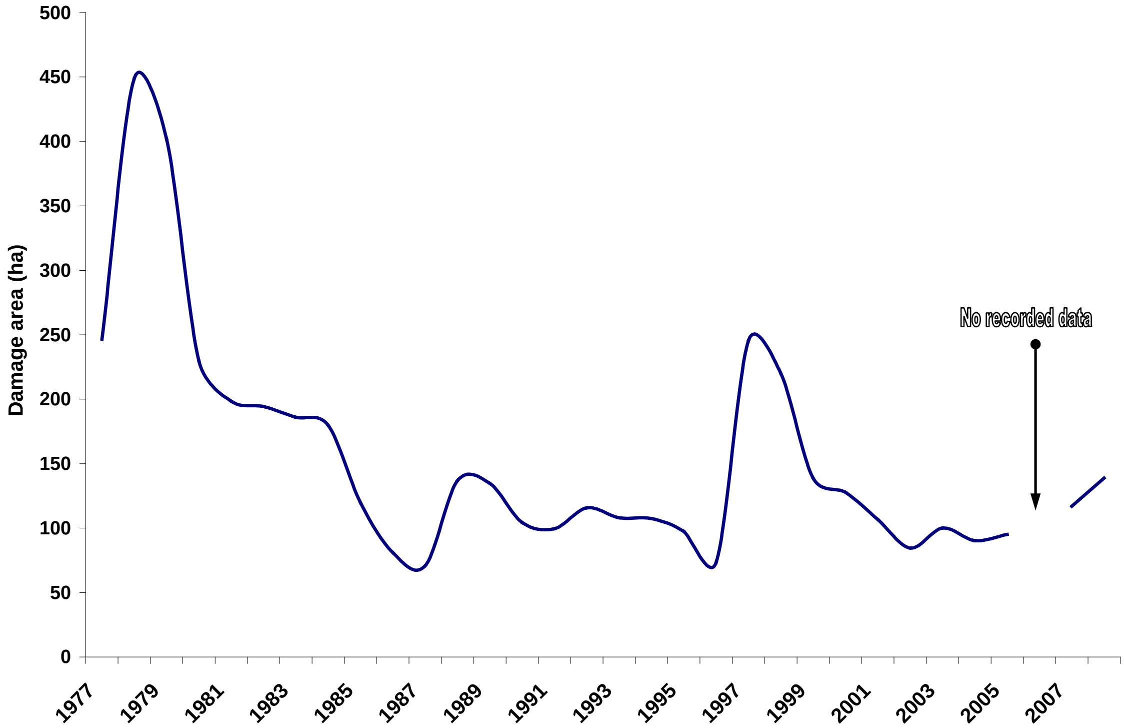


Figure 7.3. Area damaged by rats in Indonesia from 1977 to 2008.

South Sulawesi is new to the ACIAR-funded rodent management research work, with research activities since only 2006. It was therefore important to highlight what has been achieved here and the different situation compared to West Java (where rodent research work has been going on for around 12 years). There has, however, been some, limited exposure to EBRM through training and visits by ACIAR and CSIRO staff in the past.

7.2 KAP&SE survey

7.2.1 Indonesia

West Java

Social and farming profile

A typical head of household in Karawang district is a 48 year old male with 22 years farming experience and whose primary occupation is farming. He is married with 2.8 children.

85% of farmers interviewed from the district own their own land (either bought or inherited), while 21% share-crop their land and 7% lease.

Crop pests

In the 2005-06 crop season, stem borers (46.3%), rats (23.9%) and brown plant hoppers (20.6%) were ranked as the most significant constraints to crop production.

Rats were responsible for an estimated 7.5% and 9.8% losses to the wet and dry season crops respectively.

Experience of rodent management

In general, the farming community agreed that community management actions had been more effective than individual actions in controlling damage (93.3%); that community control had been most effective if implemented before tillering (83.7%); and that general farm hygiene (87.6%) and synchronous planting (82%) had reduced rat numbers.

Areas of difference between farmers appeared when considering the effect of bund size on managing rodents and the specific timing of Community Actions (see Figure 7.4).

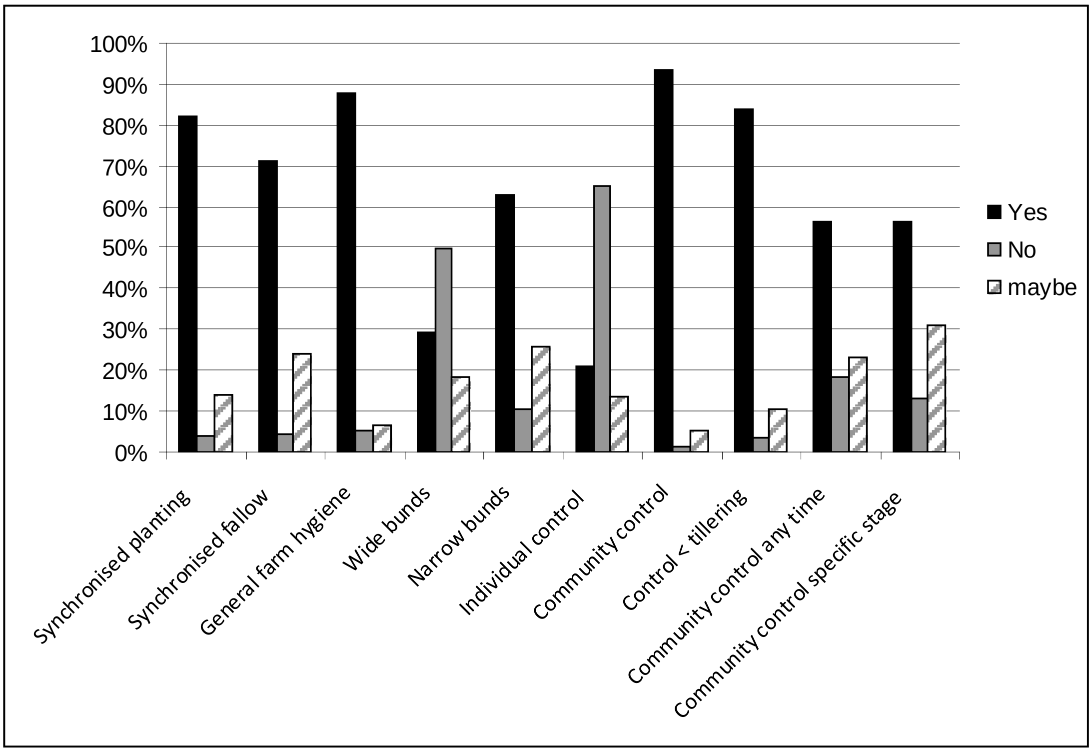


Figure 7.4. Farmer knowledge and past experience of effective rodent control practices (percentage of respondents, Karawang district, West Java, Indonesia).

Beliefs and actions

Karawang farmers strongly believe control of rats is important (100%), possible (97%) and would lead to higher yields (98%) (Figure 7.5).

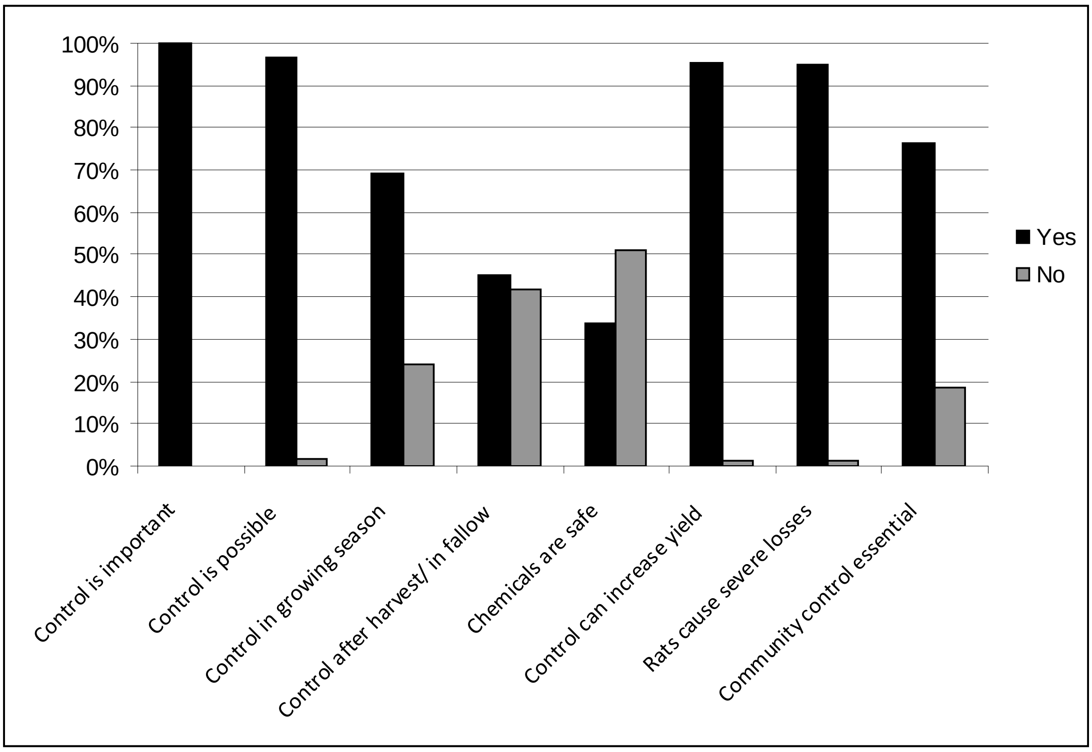


Figure 7.5. Farmer beliefs about rat management (percentage of respondents, Karawang district, West Java, Indonesia).

For most questions, the majority of farmers responded in a consistent way. Divergence was evident in responses to whether control needs to be applied after harvest (44.9% yes; 41.6% no) and also whether the use of rodenticides was safe for humans, other animals and the environment (33.7% yes; 51.1% no).

With respect to management on the ground (ie what practices farmers are actually applying), the most frequent control practices were synchronous cropping (35.5%) and hunting (32.2%) – both community actions (Figure 7.6).

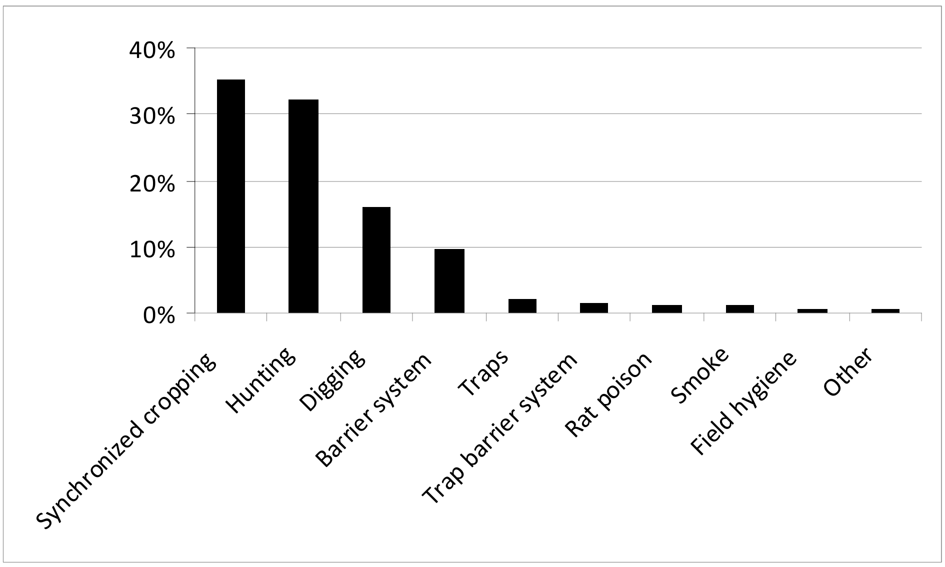


Figure 7.6. Rodent control practices applied on farmer land (percentage of respondents, Karawang district, West Java, Indonesia).

Further, they considered hunting to be the most effective control practice (because many rats can be killed), followed by synchronous planting (because rats are easy to kill at this time).

Decisions about implementing management practices were mostly based on farmer's own experience (57%) or on their partner's experience (37.4%). However, at the time of the survey, community control efforts were predominantly organised by the government (50.3%) or by farmer groups (25.5%).

Although plastic barriers were in use, 80.7% of respondents had not heard of the Trap Barrier System at this point in the project.

Social cohesion and information exchange

Farmers rated the social unity of the study villages as average (35.2%) or good (63.1%). 89.8% of farmers worked on a community project during the past year, of which 97.2% offered their services voluntarily.

The average household head attended 5 local ceremonies each year and 17 village/ farmer group meetings.

78.1% of respondents belonged to a farmer cooperative (average membership of 33 people), 19.3% were members of a farmer group (average size of 43 members) and 14.9% were members of a religious organisation (average size of 24 members).

Despite these membership rates and sizes, farmer groups and other associations were not used as major sources of information about new farming technologies.

The agents that farmers relied on most heavily for this information were farm neighbours, relatives and agricultural extension staff.

Traditional forms of mass media (TV, pamphlet, bulletin, newspaper, radio) were not influential in this district for disseminating information about agricultural practices (Figure 7.7).

73.8% of respondents felt that their access to information had improved in the last 5 years and 42.5% of them felt that this was due to the presence of Primatani.

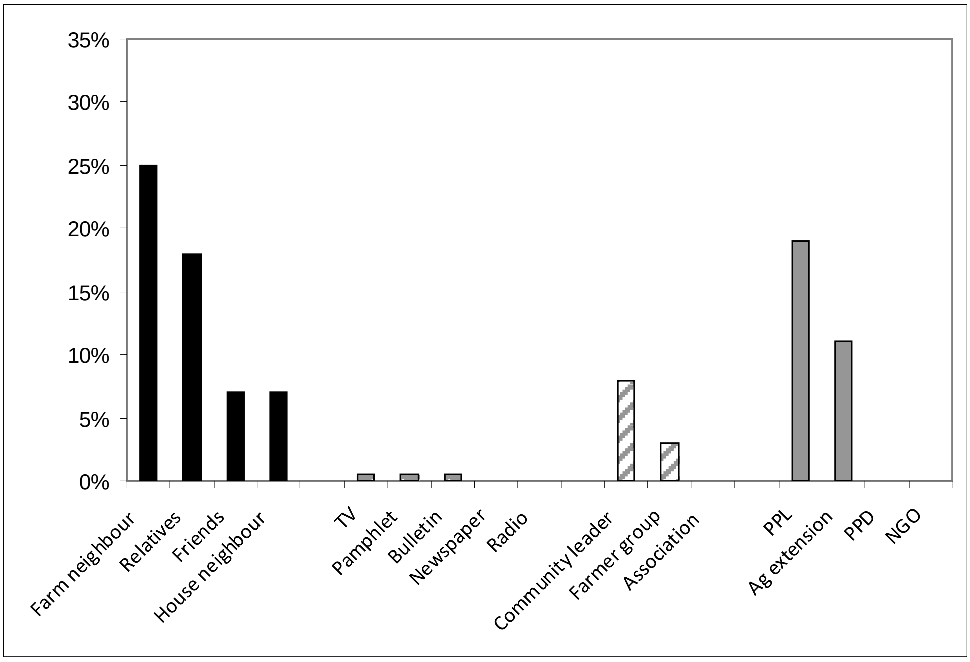


Figure 7.7. Most important information sources for agricultural technology (percentage of respondents, Karawang district, West Java, Indonesia)

South Sulawesi

Social and farming profile

A typical head of household in Pinrang district is a 44 year old male with 19 years farming experience and whose primary occupation is farming. He is married with 2.3 children.

61% of farmers own their own land (either bought or inherited), while 37% share-crop their land and 2% lease.

Crop pests

In the 2005-06 crop season, rats (39.4%), brown plant hoppers (16.7%) and stem borers (15.5%) were ranked as the most significant constraints to crop production.

Rats were responsible for an estimated 25.2% and 26.9% losses to the wet and dry season crops respectively.

Experience of rodent management

There was general consensus that community management actions had been effective in controlling damage (97.3%). There was also agreement that farm hygiene (91.1%) and synchronised planting (87.1%) had been effective activities in managing rodent numbers (Figure 7.8).

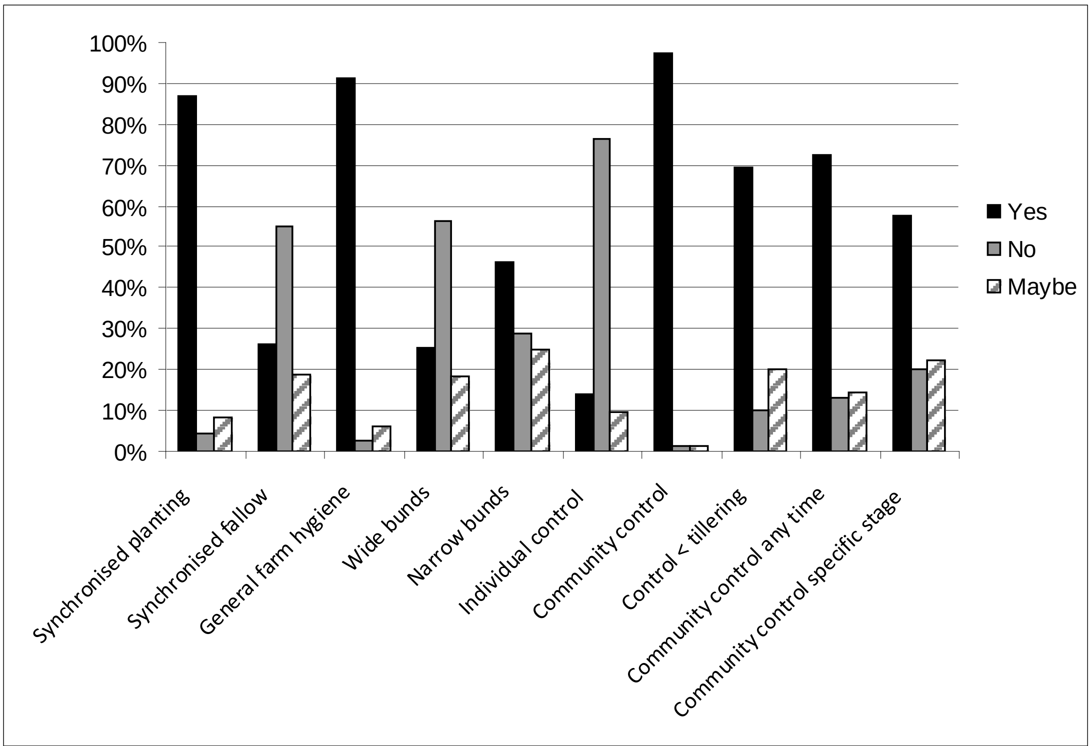


Figure 7.8. Farmer knowledge and past experience of effective rodent control practices (percentage of respondents, Pinrang district, South Sulawesi, Indonesia).

Beliefs and actions

Pinrang farmers strongly believe control of rats is important (100%), possible (94%) and would lead to higher yields (94%) (Figure 7.9). 99% of farmers believe that rats can only be controlled if farmers work together.

For most questions, the majority of farmers had fairly consistent attitudes towards rodent management. Greatest divergence was evident in responses to whether control needs to be applied after harvest (45.8% yes; 53.6% no) and also whether the use of rodenticides was safe (32.3% yes; 67.2% no).

With respect to management on the ground, farmers stated that the common control practices were poisoning (27.6%) - predominantly an individual action – followed by digging (22.4%) and synchronised cropping (18.6%) – both conducted as predominantly community actions (Figure 7.10).

Despite the lower incidence of synchronous planting, farmers considered it both the most effective and most preferred control practice. Poisoning was preferred over digging and was also considered to be more effective.

Most decisions about implementing management practices were based on farmer's or their partner's experience (76%) or with input from local extension staff (15%). Half community control efforts were organised by farmer groups, 32% by local government and 18% by agricultural extension staff.

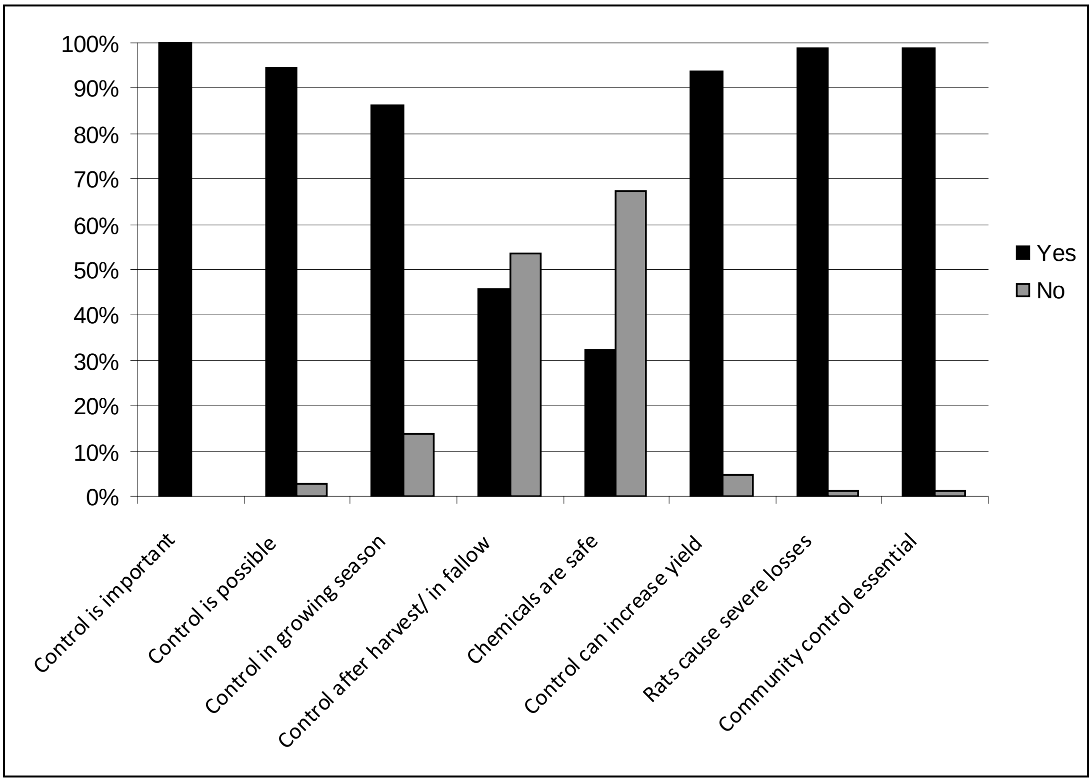


Figure 7.9. Farmer beliefs about rat management (percentage of respondents, Pinrang district, South Sulawesi, Indonesia).

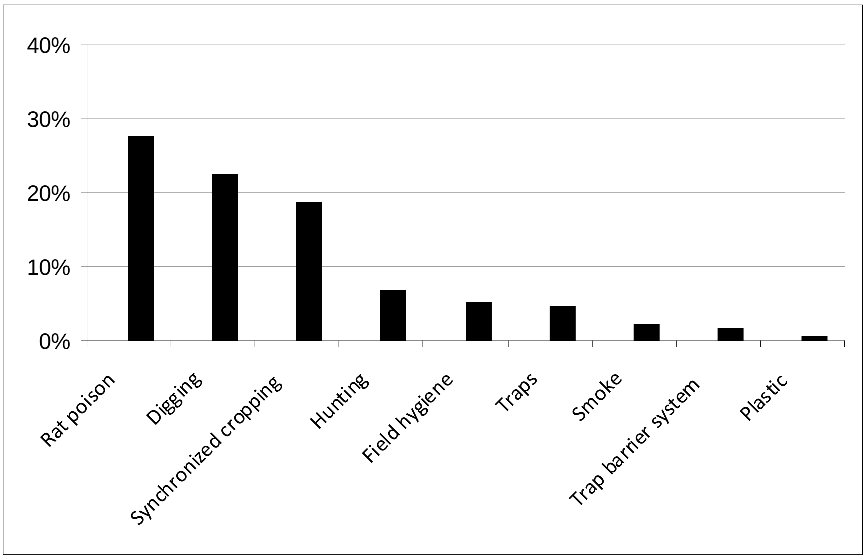


Figure 7.10. Rodent control practices applied on farmer land (percentage of respondents, Pinrang district, South Sulawesi, Indonesia).

Social cohesion and information exchange

Farmers rated the social unity of the study villages as average (32.8%) or good (57.8%). 94.7% of farmers worked on a community project during the past year, of which 59.1% offered their services voluntarily. The average household head attended 15 local ceremonies each year and 13 village or farmer group meetings.

The agents farmers relied on most heavily for information about new farming technologies were community associations and agricultural extension staff (Figure 7.11). 87.2% of respondents felt that their access to information had improved in the last 5 years.

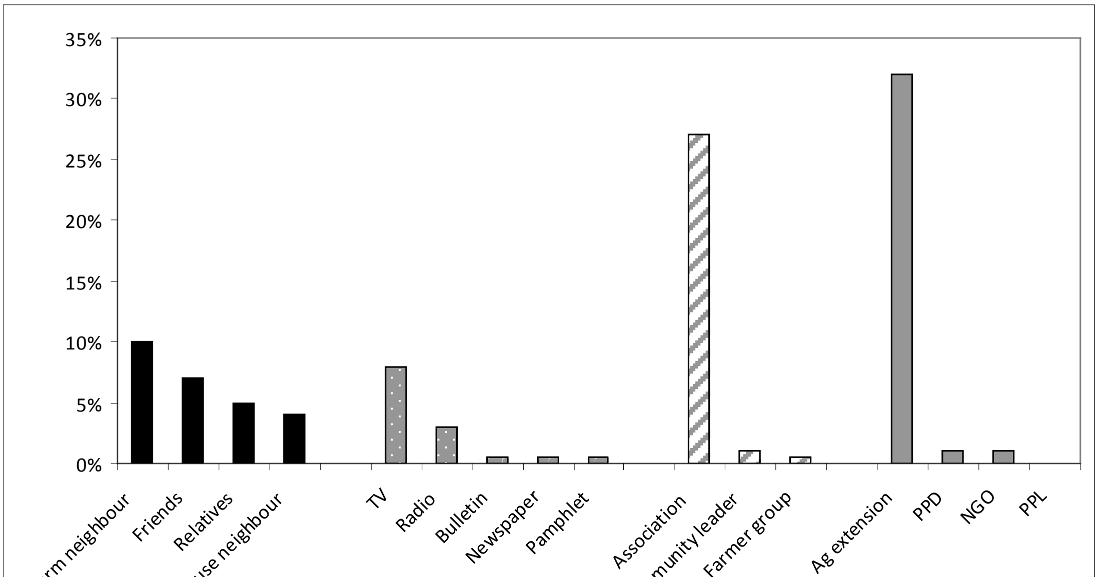


Figure 7.11. Most important information sources for agricultural technology (percentage of respondents, Pinrang district, South Sulawesi, Indonesia)

Summary

The two locations had a similar social profile and similar assessments of social unity. Responses suggest that the Pinrang (South Sulawesi) communities had more social interactions while the Karawang (West Java) communities had more planning or governance interactions.

Experience, knowledge and beliefs towards rodent management were also similar across the two locations, particularly in the conviction that Community Action is more effective than individual action in managing rodents.

In Karawang, Community Actions are the most commonly practiced and are also perceived by farmers to be the most effective. Of the four major community action promoted by the project, two – synchronous cropping and hunting – were favoured above others.

In Pinrang, the most common management practice was poisoning, applied individually. This is despite 1) Pinrang farmers were stronger in their belief that Community Action is necessary to control damage; 2) less farmers believed that chemicals were safe to non-target animals, including humans; and 3) farmers preferred synchronous cropping as a management action, and considered it more effective than poison.

Given the scale of the rodent problem in Pinrang it is assumed that farmers are applying whatever method they believe has the most immediate impact. Digging and hunting were the next most common practices and these were applied communally.

Although there are healthy farming networks in Karawang, farmers relied on neighbours and relatives for information and advice about new farming practices. In Pinrang, extension staff had a significantly more prominent role in both information transfer and assistance with decision making. In both locations, traditional media was not seen as an important mean of information dissemination. This has important implications for the future delivery of knowledge, technology or new practices.

In both locations, potential leverage points for future rodent management initiatives were:

- identifying specific crop stages that are most effective for community control;
- optimal bund width for managing populations;
- application of community actions post-harvest; and
- safe and timely use of rodenticides.

Comparative analysis with post-project surveys was not possible as the data were not forthcoming.

7.2.2 Vietnam - Ha Nam

The farmers believed that rodent pest is one of the key factors that limit rice production (86%). Thus, all the farmers viewed that rodent management is important.

The adoption of CTBS was almost not existent in the study villages. It was only practiced in the pilot sites involved. The reported constraints were high investment costs (66%) which includes both monetary and transaction (time involved). Also, where there was a government subsidy, farmers would not practice it because of the difficulty in doing early planting, considering their small farm sizes (72.2%).

There was a strong shift in the nature of farmer participation for different rodent control practices (Table 7.9). There was a strong shift away from the use of rodenticides such that most farmers that used rodenticides conducted this as an individual practice. More importantly, there was a shift towards the use of integrated community actions from 36% identified in the pre-survey to 62% in the post-survey.

Table 7.9. Changes in percentages of farmer rodent control practices from KAP&SE survey, Ha Nam, Red River Delta, Vietnam. Control strategies were categorised as individual, group and community. The post-survey covers only 50% of total sample size. Integrated includes synchronised cropping, hunting, barrier system, digging, field hygiene, smoke-out, trapping and water pumping.

Control practice	Pre-survey (Baseline) (n = 302) (%)	Post-survey (n=148) (%)
Rodenticide	*99*	*47*
Individual	7	33
Group	26	7
Community	71	7
Electricity	*2*	*0*
Individual	2	
Group	0	
Community	0	
Integrated	*100*	*99*
Individual	90	57
Group	32	44
Community	36	62

However, Community Action was practiced in all the pilot sites, conducted four times a season. Normally, it is done during land preparation, 10-15 days after planting (DAT), 30-45 DAT and at booting stage. Community participation was through members of farmers' cooperatives, farmers and their household members, and the rodent control group. The Community Action is usually organised by sub-PPD and respective plant protection station (PPS) of the district in collaboration with the farmers' cooperative and the village People's Committee, the local executive body that carry out local administrative duties.

There are also strong, coordinated linkages between local political and extension institutions in northern Vietnam. 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. The farmer's cooperative, whose head is an official of the village People's Committee, is the direct link between the government and farmers.

7.2.3 Vietnam - An Giang

Rat damage was perceived as a second highest limiting factor to rice production and as an important rice pest to control (50%). Farmers also observed regular rat damage causing severe yield losses (98%). Thus almost all farmers believe that controlling rats is highly important and rat damage can only be controlled if farmers work together.

As with Ha Nam, there was a strong shift from individual rodent control actions in the pre-survey to group or community actions in the post-survey (Table 7.10). There was a 53% decrease in the percentage of farmers implementing rodenticides as individual actions, and a 100% decrease in the use of electricity as a rodent control method. There was a strong shift towards farmer conducting integrated rodent control actions away from individual actions to group or community-based actions.

Table 7.10. Changes in percentages of farmer rodent control practices from KAP&SE survey, An Giang, Red River Delta, Vietnam. Control strategies were categorised as individual, group and community. Integrated includes synchronised cropping, hunting, barrier system, digging, field hygiene, smoke-out, rounding up with net, trapping and water pumping.

Control practice	Pre-survey (Baseline) (n = 300) (%)	Post-survey (n=300) (%)
Rodenticide	*68*	*31*
Individual	64	30
Group	3	1
Community	0.5	0.5
Electricity	*24*	*0*
Individual	22	
Group	1	
Community	0	
Plastic fence	*9*	*1*
Individual	*5*	*0.7*
Group	*2*	*0.7*
Community	*2*	*0*
Integrated	*86*	*94*
Individual	64	38
Group	17	46
Community	5	10

Similar to Ha Nam, the adoption of CTBS was almost none. It was only practiced in the pilot sites involved. Likewise, the reported constraints were high material costs (78 %) and time requirements. In case of government subsidy, farmers would not practice it unless there is severe rodent damage, because aside of the difficulty in doing early planting, traps are either easily damaged or stolen.

Like in Ha Nam, Community Action was practiced in all the pilot sites, and conducted three times a season. Normally, it was done during land preparation, 10-15 days after planting (DAT), and 30-45 DAT. Community participation was through farmers' and their household members, members of village associations such as farmers' association, youth union, women's association, village security group and at times, even school children. The Community Action is organised by PPD and the plant protection station (PPS) for each district in collaboration with the village People's Committee.

7.3 Diffusion of EBRM (Vietnam)

Sub PPD Ha Nam has used a variety of pathways to disseminate EBRM to farmers. These were through TV via a local provincial channel and VTV2 which is a channel of Vietnam National Television; radio broadcasting at all levels: province, district, commune, and village; and training of trainers to sub-PPD staff in a number of provinces and staff of World Vision Vietnam (particularly in Hung Yen province); farmer training and implementation of Community Action.

The local TV channel was broadcasted since January 2009, on 8pm every Monday in a segment titled, “Things farmers should know”. A segment on rodent management was broadcasted at the time of season when rat control is most important, for example during land preparation, tillering, etc. The VTV2 of Vietnam National Television broadcasted information on rodent management since April 2009. Some farmers reported they had watched it 3 times; the latest broadcast was in September 2009. EBRM was also published in the local Ha Nam newspaper, with guidelines on rat control methods and timing of application.

Community action was initiated in all the remaining districts of Ha Nam at both the commune and village levels. Farmer training was normally conducted prior to the implementation of Community Action for rodent management. In 2009, four CTBSs were set up the summer season in the three communes in Hung Yen: one each in Tong Tran and Minh Tien communes, and two in Vu Xa commune under the initiative of World Vision Vietnam. Ha Nam Sub PPD staff was invited to deliver a training course on CTBS for farmers in Hung Yen, supported by World Vision Vietnam.

Similarly, sub-PPD An Giang promoted rodent Community Action in the province by organising Community Action campaigns in all communes of the two district pilot sites in 2008. These community campaigns were implemented two to three times in a season in these diffusion communes. In 2009, Community Action was organised in at least one commune for the remaining nine districts of An Giang province. As mentioned earlier, assessment of EBRM diffusion was not done in An Giang but done only in Ha Nam due to financial and time constraints.

More than 60% of the total respondents from Ha Nam and Hung Yen have heard about CTBS, while only 35% from Nam Dinh had known of it. Mostly, the farmers had heard of it from TV, and sub-PPD or PPS. Because of high investment costs and technical constraints (early planting), none of the farmers had established their own CTBS, except from those in the demonstration fields. Also, farmers perceived that the rat population was too low to justify investing in a CTBS.

The practice of Community Action was implemented in all the diffusion sites surveyed: six communes from Ha Nam pilot sites, two communes from Nam Dinh, and three communes from Hung Yen. Community Action was done four (4) times a season, during land preparation, 7-25 days after planting (DAT), 30-45 DAT and at booting stage in both summer crop and spring seasons of 2009. All farmers participated for at least two Community Actions particularly during land preparation and at 7-25 DAT. More than 40% participated for the last two Community Actions but most are done by rodent control groups, who do community trapping regularly for the whole season. Synchrony of cropping, field hygiene and various physical methods for catching rats such as hunting, digging, and trapping, were commonly practiced for the Community Action. Rodenticides are also used, but the frequency of application was dramatically reduced from three to one applications in a cropping season.

Community participation was through members of farmers' cooperatives, farmers' and their household members, and the rodent control group. The farmer household members include the spouse and children. The Community Actions were usually organised by sub-PPD and respective plant protection station (PPS) of the district in collaboration with the farmers' cooperative and the village People's Committee, the local executive body that carry out local administrative duties.

Normally, the sub PPD sends documents and guidelines to PPS early in the crop season, and when emergency pest situations arise. They also meet directly to discuss about pests and rodent problems in the districts. Based on specific situations of rat incidence in each district, PPS prepares and sends documents and guidelines to leaders of agricultural cooperative and/or with plant protection staff, who in turn tailored rat management practices based on the specific condition of the commune. In many cases, rat management practices differed among villages in one commune depending upon the need.

The effective pathway for EBRM implementation in northern Vietnam was through the strong, coordinated linkages between the local political and extension institutions. The sub-PPD, which is responsible for extending crop-protection technologies, has strong linkage with the People’s Committees at the provincial, district, and village levels. It provides the technical support for crop protection technologies like the EBRM to farmers and farmers' cooperatives. The farmers' cooperatives on the other hand serve as a bridge between the government and farmers. The head of a farmer's cooperative is an official of the village People's Committee. Also, plant protection concerns of agricultural cooperatives are under the supervision and guidance of the plant protection system (PPS for district level and sub-PPD for province level). Farmers' cooperatives are the avenue for organising, mobilisation of farmers' participation and rodent control group for rodent Community Action. The People's Committee provides the political and financial support to farmers' cooperatives. At times, the PPD provides financial support through the department of agriculture via farm demonstrations, training and field days.

7.4 Governance and institutional arrangements for EBRM (Indonesia)

Key informant interviewing in Indonesia yielded strong messages regarding the importance of coordination among and between civic and government stakeholders. It was found that disjointed governance undermines the farmer cooperation necessary for community based rat management. Disjointed governance was pinpointed as an EBRM barrier on several fronts: whether spatial patterns of rat damage and agency attention could be overcome; whether the requirements to make a technology work could be met; whether effective incentives and penalties could be devised, and whether farmer groups functioned at their best.

The spatial arrangement of rat damage affects cooperation between farmers. Because rat damage is high along village, estate crop and irrigation channel borders, farmers with fields remote from borders are inclined to free ride by not participating in Community Actions. The spatial separation of land ownership from farming labour can affect cooperation between farmers. Community based action is harder to establish where farmers labour on behalf of urban owners and require permission from those owners to participate in community based actions. This situation was more pronounced in West Java, due to the proximity of Karawang District to Java's cities. In South Sulawesi, owners and labourers both lived in the same rural context and communicated regularly. Division of attention between urban and agricultural issues were found at each of the project subdistricts. In South Sulawesi, the rice growing areas closest to the town of Pinrang evidenced more diluted institutional support for EBRM. In Karawang district, West Java, the proportion of public monies devoted to agriculture is falling due to rapid land conversion and urbanisation.

The more complex the EBRM technology, the larger the demands upon coordination among and between civic and government stakeholders are necessary to make it work. For example, CTBS requires early irrigation waters to be delivered and collective investment in seed, insecticide, fertiliser and labour to be organised. Farmer groups lacked the capacity to tackle these extra requirements. However, leading individual farmers in South Sulawesi were willing to co-invest with agricultural agencies in a larger and permanent (concrete) CTBS if the size of the trap crop was increased tenfold (from 10 m square to 100 m square) as this would make the extra labour needed to control the pests attracted to the crop worthwhile. The simpler technology of LTBS is less demanding of governance both because it does not require out of season inputs and because it answers the spatial problem that rats migrate across irrigation channel, village and estate crop borders. Co-investment with agricultural agencies in one LTBS, the approach adopted in South Sulawesi, was sufficient to trigger further investment by farmer groups.

It was found that the provision of incentives by agricultural agencies is crucial for the initial investment in EBRM in order to demonstrate to farmers how effective community based strategies can be. Subsequently, however, free riding is best dealt with at the local level where penalties can be both agreed to as legitimate and realistically enforced. For example, a leading Pinrang farmer, having co-invested in a permanent 100 m square CTBS with an agricultural agency, threatened to release the rats caught in it onto his neighbours' fields in a successful negotiation of cost sharing (assistance planting the trap crop).

The KIIs in Indonesia also revealed that community based rat management is highly dependent upon strong, effective leadership of farmer groups. Famer groups which functioned well did not tolerate credit default and sought to build surpluses that could be devoted to investing in LTBS materials. They encouraged problem solving and experimental initiative which leads to the learning necessary for ecologically based pest management techniques. They challenged non-participation in collective activities such as rat management. Finally, good leaders worked in partnership with agricultural agencies so as to access outside resources in a manner that met both agency and local goals.

7.5 Modelling

7.5.1 Integrative modelling

The primary goal of the integrative model was to create a broad whole-of-system perspective that could be used to examine how the different components of the social-economic-ecological system interacted to determine the success of rodent control programs in the different case study sites in Vietnam and Indonesia. The major contribution of this style of modelling was as a communication tool to illustrate the importance of major drivers of rodent control success to key stakeholders: government staff, extension staff and farmers. The secondary contribution was to demonstrate as a proof-of-principle that such an integrated model could be developed further to provide real quantitative insights into rodent control systems.

To extend the detailed biophysical model described in Section 5.3, we created a powerful visual user-interface suitable for running interactive workshops in-country via translator. This interface was displayed to large audiences (5 - 30 people) via a data projector, and facilitated: 1) a self-explanatory display of the net effects of rodent damage and management on crop productivity; 2) visual plots of net rodent population, net rice production and net economic profit; 3) a simplified set of model parameters to be altered during the interactive workshop to show the outcomes of community recommended management practices relative to techniques like Community Trap Barrier Systems.

Figure 7.12 shows a snapshot of one such model run. The right hand side of Figure 7.12 shows the visual representation of the rice field, rodents, and farmers or rat controllers. Realistic rice field and irrigation channel and paths patterns were extracted by visual processing of Google Earth™ imagery (Google Inc. 2009) local to the case study area. Net local within-field rice productivity as calculated by the model described in Section 5.3 was represented by increasingly dark green colour of the field with increasing rice productivity. In this way synchronicity of planting, net growth rates of rice and damage due to rats were all immediately visible to the audience. Rats were represented by red rodent shaped icons that moved around the landscape and reproduced as described in Section 5.3. Rat catchers and farmers were represented in the landscape as blue people-shaped icons that changed their movements and behaviours depending on the rat control method being applied (e.g. hunting, trapping). Traps were represented as small red icons, and linear barriers (fences) were represented as black lines. Community trap barrier systems, therefore, were represented as a highlighted field in the centre of the simulation, surrounded by a black fence with red traps inside the field. As described in Section 5.3, once the sowing and harvesting schedules, fences and traps were defined like this for a Community Trap Barrier System, the natural behaviour of the rats automatically lead to the ecological dynamic that makes CTBS systems work. Moreover, the dynamics were clearly visible on the screen, along with the impact on rice productivity and household profit.

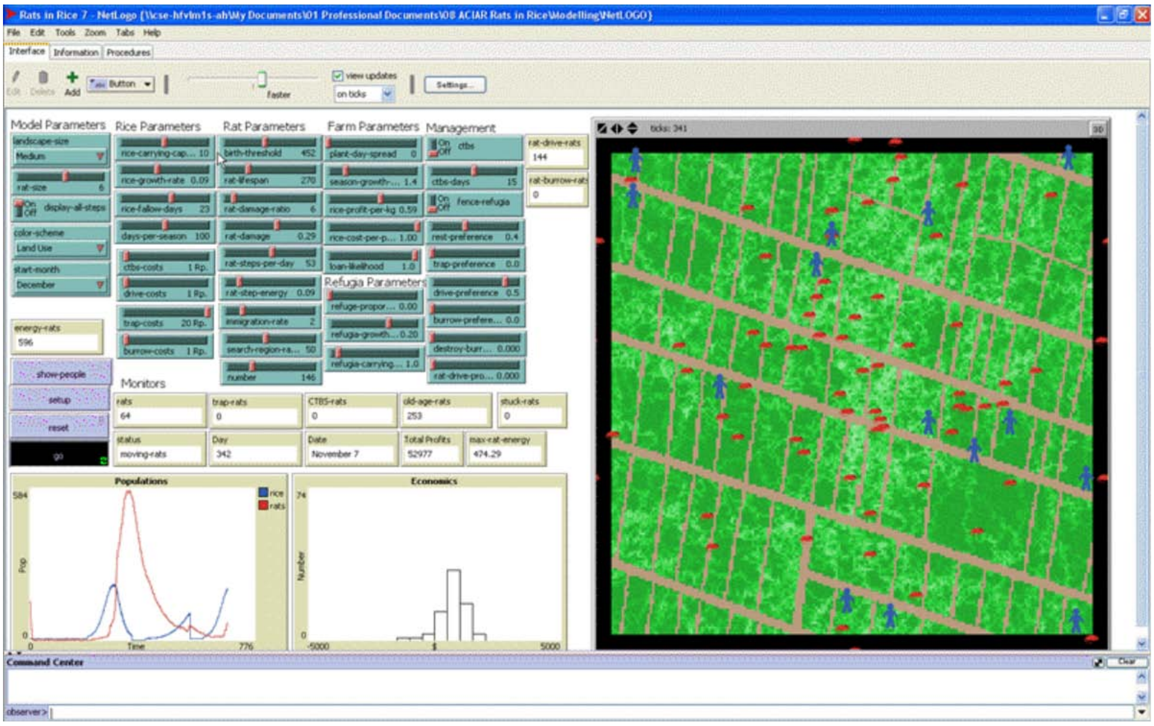


Figure 7.12. Snapshot of a run of the integrative model. This shows a visual representation of the rice field with rats running around causing damage to the growing rice crop and farmers undertaking rodent control activities. The upper-left of the screen is dedicated to a range of adjustable sliders to influence the rice crop, rat population, farm characteristics and rodent control. The lower left reports results (rice yield, number of rats and economics).

The lower left side of Figure 7.12 shows the real time plots of rice productivity, rodent population and net economic profit (including rice production, rat damage, and costs of rodent control). The upper left side of Figure 7.12 shows the various simplified controls accessible to the workshop facilitator to change the nature of the system as requested by the workshop participants to immediately visualise the outcome of different management strategies.

For the purposes of the participatory workshops, the quantitative precision of rice growth, rodent population and damage, and rodent control and household economic sub-components was not as important as the coherent interaction of all the components together to produce feasible system level outcomes. Moreover, many of the studies informing the sub-components of the model were still being conducted at the time the workshops were run. Even more importantly, the purpose of the interactive workshops was to collect community input into the model construction. Therefore, simple initial versions of the model based on reasonable estimates of model parameters were prepared prior to the workshops, and updated with input from each of these sources afterwards.

The key outcome of the integrative modelling part of the project, therefore, was the three participatory workshops held in An Giang and Ha Nam in Vietnam, and South Sulawesi in Indonesia. The workshops were conducted via interpreters with government staff and extension officers, but following their success they were also presented to farmers in some of the case study sites. Workshops were split into three segments: 1) the model structure was presented on screen and described via interpreter to build an understanding of the power of the approach; 2) several rodent control scenarios including hunting, trapping and community trap barrier systems were displayed and explained via interpreter; and 3) workshop participants were asked for their input to the various data required for the model, especially: sowing and reaping dates and synchronicity, economic inputs to and outputs from the system, and preferred rodent control methods throughout the season;

and finally, participants were asked to identify scenarios they would like to see modelled in more detail.

Figure 7.13 shows one example of the types of data collected during the feedback portion of the participatory workshops. Much of this data was known from the long history of formal research in these case study areas, but the process of explicitly asking participants often provided new insights on the diversity of different management strategies used, and more importantly, gave participants ownership of the research process - letting them 'discover for themselves' why CTBSs are an effective ecological control method, for instance - and letting them decide whether the gains from CTBS were worth the cost of a community-based control method.

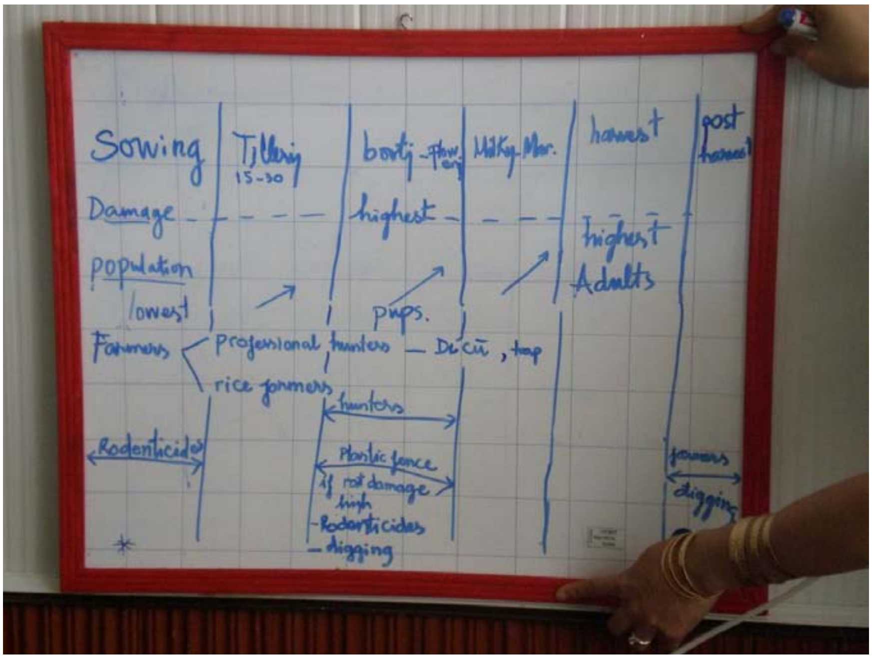


Figure 7.13. Example of the type of data collected during the participatory workshop conducted with extension staff.

The participatory workshop method was identified as a very successful and effective technique for communicating the often subtle and complex dynamics of ecological rodent control by participants at the time of the workshops. In particular, the very visual demonstration of the method by which community trap barrier systems harness simple ecological drivers to catch large numbers of rats was obviously a "light bulb" moment for many participants, based on their reactions.

One of the real powers of this agent based modelling approach is the literal nature of the models created. That is, because: 1) rice is modelled as plants that grow each day to maturity which are then harvested; 2) rats are modelled as animals that move around the landscape eating rice and reproducing; and 3) farmers are modelled as people that make choices each day about how to spend their time sowing or reaping, controlling rats or spending time on other enterprises, it makes it very easy to interact with people that do not relate to more abstract modelling techniques. Simple questions can be asked, such as "how many days a week do you spend hunting rats?", move a slider on the user interface, and see the outcome of a respondent's answer directly.

On the other hand, with this same modelling technique it is also possible to generate formal quantitative analyses of economically or ecologically optimal management strategies that can be used to inform government policy or management decisions (e.g. Happe et. al. 2006). In this case, of course, viewing individual scenarios via a graphical user interface is not the preferred mode of analysis. Parameters of the model must be anchored by study of the fundamental ecology, or economics, or social interactions via participatory workshops in order to allow more formal quantitative analysis.

By running thousands of repetitions of the model and scanning various management parameters, or investigating different scenarios, formal estimates of household or community economic benefit or ecological sustainability can be made, and optimal management strategies identified. The importance of these results are that they analyse system-level effects - whereas rodent population modelling can identify the best control techniques for reducing the rodent population, and household economic modelling can identify the best mix of expenditure for each household - a systems-level integrative model can identify the best set of strategies for the system-as-a-whole, for example, to maximize household or community profit by applying a mix of different management strategies throughout the rice growing season.

The results generated throughout this project show the potential of this technique in the case of community rodent control in Southeast Asia. More resources would be required to fully validate the various sub-components of the model and run the thousands of simulations required to generate recommendations for management in different regions. However, the results generated throughout the participatory workshops show that the model as constructed has the flexibility and quantitative foundation to be extended to this point in future, if required.

7.5.2 Economic modelling (An Giang, Vietnam)

CA and CTBS leads to significant benefits from cost sharing among farmers, and substantial community benefits from increased yields and lower aggregated costs.

From the two farm types that were identified using statistical cluster analysis, Farm Type 1 (FT1) generally holds smaller blocks of land (on average 2.5 ha) and produces less rice per hectare, ranging from ~2700 to ~4750 kg/ha (depending on the harvesting season; without rodent control) then farms corresponding to Farm Type 2 (FT2), who own larger blocks of land (on average 5.1 ha) produce ~45% more production (ranging from ~3850 to ~7300 kg/ha, depending on the harvesting season; without rodent control). For each of these farm types, the BCA (see Section 5.3.7) was performed at various levels of control intensity and community participation. At NC, returns for FT1, with yields based on APSIM modelling and a rice price of 4200 VND range from ~11M VND to ~20M VND, depending on harvesting season. For FT2, profits range from ~16M VND to ~30M VND. As FT1 produces, on average, less rice per hectare then FT2, yield related costs such as harvesting are less for FT1. At this stage, variable input costs per hectare are assumed equal, hereby neglecting potential differences in prices due to 'bulk buying' of inputs by individuals. Subtracting costs from benefits, at NC, profits for FT1, with yields based on APSIM modelling and a rice price of 4200 VND range from ~3.5M VND to ~7M VND, depending on harvesting season, where for FT2, profits range from ~5M VND to ~10.5M VND.

For CTBS and CA financial gains and or losses for each farm type were calculated for each harvesting season by comparing profits relative to the NC situation. This was done for all control intensities (CI 10% to CI 100%) and community participation (P 10% to P 100%). The full results are provided in Appendix 2.

Based on these results, an 'Action decision matrix' was constructed for each farm type (Table 7.11 and Table 7.12). We assumed a control intensity of 100% so that farmer decisions are recommended based on the level of community participation. The matrix shows how different levels of participation result in different rodent control strategies that become economic for each of the harvesting seasons. For Farm Type 1 (2.5 ha small farms), CTBS was only recommended in the third harvesting season when 50% of farmers could participate, otherwise, Community Actions would be sufficient at most other times (Table 7.11). For farm type 2 (5.1 ha large farms), CTBS was only recommended in the third harvesting season when 60% of farmers could participate, otherwise, Community Actions would be sufficient at most other times (Table 7.12). Furthermore, no control (NC) was recommended in nearly all levels of participation in the second harvesting season (HS2), except at 100%. This is because of the combination of relatively low levels of rodent damage in that season (see Section 7.5.4), but also that rice grain yields were also much lower, so the benefits of conducting rodent control would always be marginal. Rodent control was always beneficial for the third harvesting season (HS3) because of the relatively high rates of rodent damage.

Table 7.11. Action decision matrix for Farm Type 1 (2.5 ha farms) based on selected rodent control strategies for harvesting seasons 1-3 and as a total with different levels of participation.

Participation	Farm type	HS1	HS2	HS3	HS Total
P 10%	FT1	NC	NC	NC	NC
P 20%	FT1	NC	NC	NC	NC
P 30%	FT1	NC	NC	CA	NC
P 40%	FT1	NC	NC	CA	CA
P 50%	FT1	CA	NC	CTBS	CA
P 60%	FT1	CA	NC	CTBS	CA
P 70%	FT1	CA	CA	CTBS	CA
P 80%	FT1	CA	CA	CTBS	CA
P 90%	FT1	CA	CA	CTBS	CA
P 100%	FT1	CA	CA	CTBS	CTBS

Table 7.12. Action decision matrix for Farm Type 2 (5.1 ha farms) based on selected rodent control strategies for harvesting seasons 1-3 and as a total with different levels of participation.

Participation	Farm type	HS1	HS2	HS3	HS Total
P 10%	FT2	NC	NC	NC	NC
P 20%	FT2	NC	NC	NC	NC
P 30%	FT2	NC	NC	CA	NC
P 40%	FT2	NC	NC	CA	NC
P 50%	FT2	NC	NC	CA	CA
P 60%	FT2	CA	NC	CTBS	CA
P 70%	FT2	CA	NC	CTBS	CA
P 80%	FT2	CA	NC	CTBS	CA
P 90%	FT2	CA	NC	CTBS	CA
P 100%	FT2	CA	CA	CTBS	CTBS

Finally, a sensitivity analysis was conducted on the variables within the model to rank the relative contribution of each of the variables, where the most influential variable for the outcome of the economic analysis is ranked with 1, the least influential is ranked 7 (Table 7.13). The most important variable was rice price, through to the least important variable being control intensity.

Table 7.13. Ranking of variables used in the economic analysis for Community Actions and CTBS. Variables with rank 1 were most influential in the model and variables with 7 were least variable.

CA Variable	FT1 Ranking	FT2 Ranking	CTBS Variable	FT1 Ranking	FT2 Ranking
Control intensity	7	7	Control intensity	7	7
Cost of control	4	4	Cost of control	5	5
Participation	6	6	Participation	3	2
Rice price	1	1	Rice price	1	1
Farm costs	5	5	Farm costs	6	5
Farm area	3	3	Farm area	4	6
Yield	2	2	Yield	2	3

7.5.3 Rodent population modelling

The *Ratty* model was successfully built using Excel. It was used to demonstrate how a rodent population could respond to control applied at various stages throughout the year and the effect of different rodent control intensities on rodent population abundance (Figure 7.14). The basic structure of the model was modified so that it ran on a daily time-step, and was combined with the rodent damage modelling discussed in the next section and incorporated into the APSIM crop model to examine the response of rice crops to different types of rodent management.

	Rate of increase	All sites Exp (*r*)	Control only	SE		Start	Untreated 100	Control	Efficacy 0%	1.3 100	Breed	Rice
Jan	0.8728	-0.2324	0.4176	0.63	9.33	Jan	87.28	0%	0%	87.28	0	0
Feb	0.7451	-0.6380	-0.8325	0.73	31.00	Feb	65.03	0%	0%	65.03	0	0
Mar	1.3593	0.1955	0.5664	0.77	62.00	Mar	88.40	0%	0%	88.40	0	795
Apr	0.5256	-0.8191	-0.7974	0.54	94.67	Apr	46.46	0%	0%	46.46	1	795
May	2.3142	0.6561	0.9422	0.94	177.75	May	107.52	50%	50%	53.76	1	795
Jun	2.5155	0.8110	1.0017	0.38	271.25	Jun	270.46	0%	38%	166.44	1	0
Jul	2.4511	0.7962	0.7273	0.18	336.50	Jul	662.92	0%	30%	466.79	0	0
Aug	0.8777	-0.2408	-0.1787	0.21	293.75	Aug	581.84	0%	23%	449.42	1	795
Sep	0.3866	-1.1042	-1.4304	0.34	101.75	Sep	224.95	0%	18%	185.57	1	795
Oct	2.4073	0.7959	0.8829	0.21	195.50	Oct	541.53	0%	13%	468.60	1	0
Nov	0.7036	-0.3592	-0.6082	0.08	41.00	Nov	381.00	0%	10%	341.54	0	0
Dec	0.5187	-0.6633	-1.1201	0.74	43.75	Dec	197.62	0%	8%	181.88	0	0
							3255.01			**2601.16**	**653.8**	

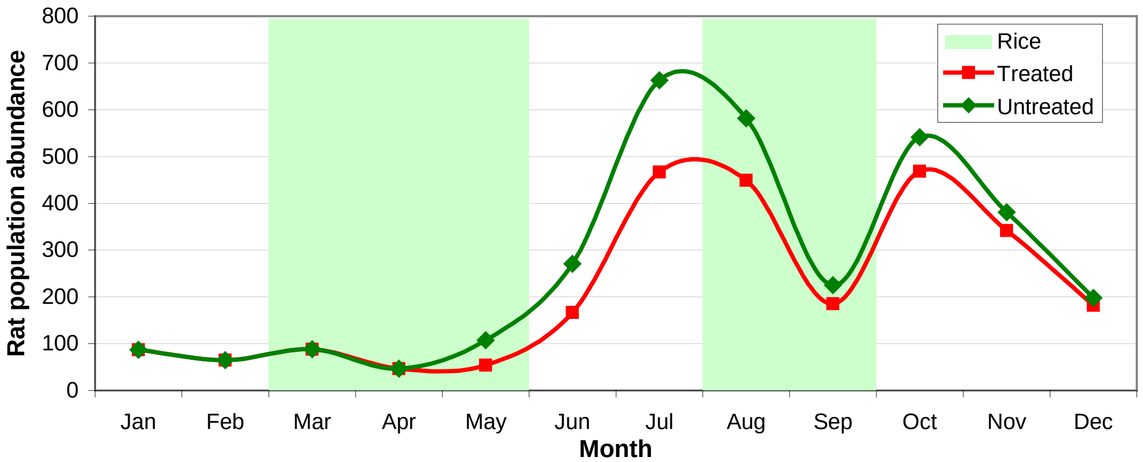


Figure 7.14. *Ratty* monthly population model built in Excel showing changes in population abundance based on rates of increase. This example shows the change in population abundance after the "treated" population was reduced by 50% in May and the lagged response and compensation of the population over time. The model was started with a nominal figure of 100 rats. The data used in the model were based on a four year population study in Vinh Phuc Province, Red River Delta from 1999 to 2002.

7.5.4 Rat damage modelling (An Giang, Vietnam)

Instantaneous damage by all pests

There were 17 pests recorded through the five years of data (Table 3). These were broadly grouped into:

- Insect pests (brown plant hopper, panicle rice mite, rice bug, rice leaf folder, rice stem borer, and white-backed plant hopper);
- Diseases (bacterial leaf blight, dirty panicle/grain discoloration, green unfilled panicle, leaf blast, leaf streak, neck blast, red stripe, rice grassy stunt virus, sheath blight, and yellow unfilled panicle); and
- Rodents.

The levels of instantaneous damage for each pest for each of the three main crop seasons are shown in Table 7.14. The main pest was the brown plant hopper (16.7% area damaged) followed by rice leaf folder (12.1%) and leaf blast (5.2%). Rodents were the pest that ranked fourth in terms of area damaged (4.2%). The rest of the pests each affected <3% of the rice crop area. These assessments occurred at a time when rodent damage was relatively low.

Table 7.14. Pests of rice in An Giang Province (percent of area damaged) from July 2004 through until November 2008 for each of the three main rice crop seasons (DX1 = Đông Xuân, HT2 = Hè Thu, Vu3) sorted from greatest impact to smallest impact. Shown are means (± 1 standard error) from five years of data and average annual total. Assessments of area of damage were made by trained Plant Protection Department staff each week throughout the year.

Pest	Area damaged (%) DX1	Area damaged (%) HT2	Area damaged (%) Vu3	Area damaged (%) Total
Brown plant hopper	20.83 ± 6.64	15.02 ± 6.69	14.18 ± 4.96	16.68 ± 3.38
Rice leaf folder	12.04 ± 1.27	12.36 ± 1.17	11.73 ± 1.77	12.05 ± 0.77
Leaf blast	6.33 ± 2.62	2.07 ± 1.84	7.33 ± 1.13	5.24 ± 1.21
Rodents	*2.08 ± 0.46*	*3.81 ± 0.77*	*6.57 ± 1.59*	*4.15 ± 0.75*
Dirty panicle/discoloured grain	0.73 ± 0.12	4.21 ± 0.98	3.42 ± 0.41	2.79 ± 0.52
Bacterial leaf blight	0.06 ± 0.04	1.06 ± 0.36	7.06 ± 1.37	2.73 ± 0.93
Sheath blight	0.33 ± 0.33	2.24 ± 0.77	3.09 ± 1.25	1.89 ± 0.56
Red stripe	3.16 ± 0.68	1.15 ± 0.46	1.21 ± 0.63	1.84 ± 0.40
Panicle rice mite	0.58 ± 0.24	1.75 ± 0.59	0.38 ± 0.14	0.90 ± 0.26
Leaf streak	0.01 ± 0.01	0.10 ± 0.06	1.35 ± 0.56	0.48 ± 0.24
Neck blast	0.10 ± 0.09	0.38 ± 0.25	0.79 ± 0.52	0.42 ± 0.20
Rice grassy stunt virus	0.00 ± 0.00	0.04 ± 0.04	1.11 ± 1.11	0.38 ± 0.37
Yellow unfilled panicle	0.01 ± 0.01	0.66 ± 0.66	0.27 ± 0.27	0.32 ± 0.23
Rice stem borer	0.28 ± 0.28	0.00 ± 0.00	0.46 ± 0.28	0.24 ± 0.13
Green unfilled panicle	0.20 ± 0.20	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.07
Rice bug	0.00 ± 0.00	0.00 ± 0.00	0.15 ± 0.13	0.05 ± 0.04
White-backed plant hopper	0.04 ± 0.04	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01

Most of these pests had similar levels of damage in the three crop seasons (Table 7.14). However, for some pests, there were some different patterns of damage depending on season. For example, damage by dirty panicle/grain discoloration was low in the DX1 crop and was highest in the HT2 crop, damage by leaf blast was low in the HT2 crop but high in DX1 and Vu3, damage by bacterial leaf blight increased from very low in DX1 and HT2 to high in Vu3, and damage by rodents increased from low in DX1 to moderate in HT2 and high in Vu3.

Instantaneous fresh rodent damage and cumulative rodent damage

The general pattern of instantaneous fresh rodent damage was similar for the DX1 and HT2 crops. Damage was low at the beginning of the crop, then increased during the middle period of rice crop growth, then decreased towards the end of the crop (Figure 7.15).

The area damaged by rodents was highest in the HT2 crop (Figure 7.15). Low levels of cumulative fresh damage observed at the end of the crops may be due to staggered harvesting and small areas of remaining unharvested crop. Damage to the Vu3 crop seemed to occur later, but damage was often much higher and yield loss was higher (note: the area of Vu3 crop is much smaller, but damage was still high).

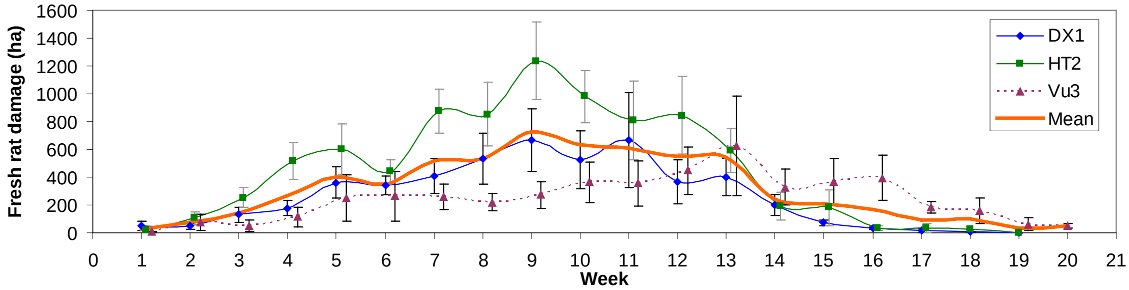


Figure 7.15. Average levels of area of fresh damage (± se) for each rice crop (DX1, HT2 and Vu3) each week after planting of rice crops showing the overall mean fresh damage each week in An Giang Province, Vietnam.

Estimated area of crop damage

The values of weekly fresh rodent damage were accumulated for each District of An Giang for each crop type. The overall level of damage increased through the seasons, DX1 with 2.08% loss (± 0.46 se), HT2 with 3.81% loss (± 0.77 se), and Vu3 with 6.56% loss (± 1.59 se). The large damage figure for the Vu3 is strongly influenced by large areas of damage and high loss in Tinh Bien district and Tri Ton district in some years. At a landscape scale, these two Districts in addition to Thoai Son each have an area of damage >13% for the Vu3 rice crop. These three Districts are located furthest from the tributaries of the Mekong River, however, the area of rice crop grown was small for Tinh Bien and Tri Ton districts.

Furthermore, some areas were damaged more than once, so the area damaged was occasionally larger than the total area sown. The overall level of estimated damage for each crop type for each year is shown in Figure 7.16. The highest damage occurred in the Vu3 crop in 2007 (12.6%).

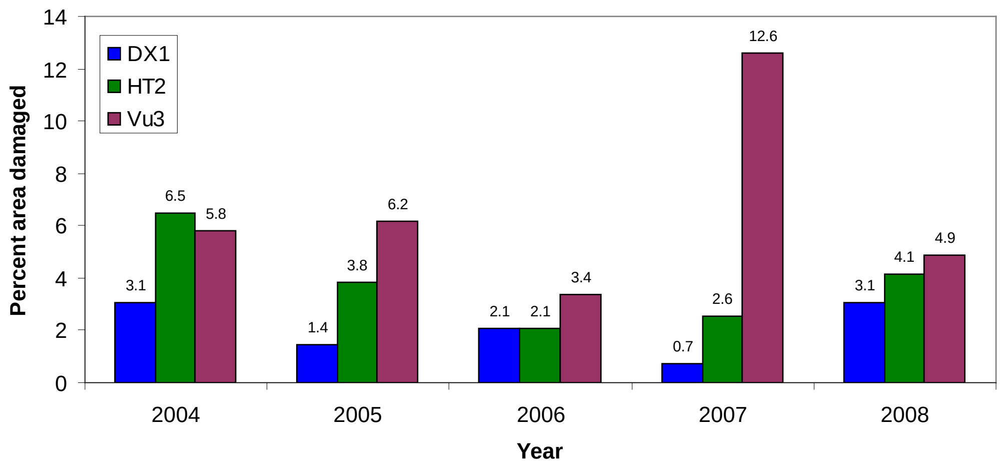


Figure 7.16. Total estimated rodent damage each of the three rice crops (DX1, HT2 and Vu3) from 2003-2008, An Giang Province, Vietnam.

Estimates of percent crop loss

There was no apparent trend in the levels of percent loss that occurred each week for the three crop types. The overall mean range of percent crop loss (minimum and maximum) for DX1 were 0 to 10.4%, for HT2 were 0.3 to 14.8%, and for Vu3 were 0.1 to 15.0%. The maximum estimated yield loss was 50% recorded in HT2 in 2007.

Percentage of area of rodent damage

The percentage of weekly fresh instantaneous rodent damage as a percentage of area of crop grown provides a measure of the relative weekly rat damage over the 5 year period. This weekly percentage area damaged was converted into a daily feeding rate (divided by 7 days) (Figure 7.17). The cyclic nature of damage over the different rice crops is evident.

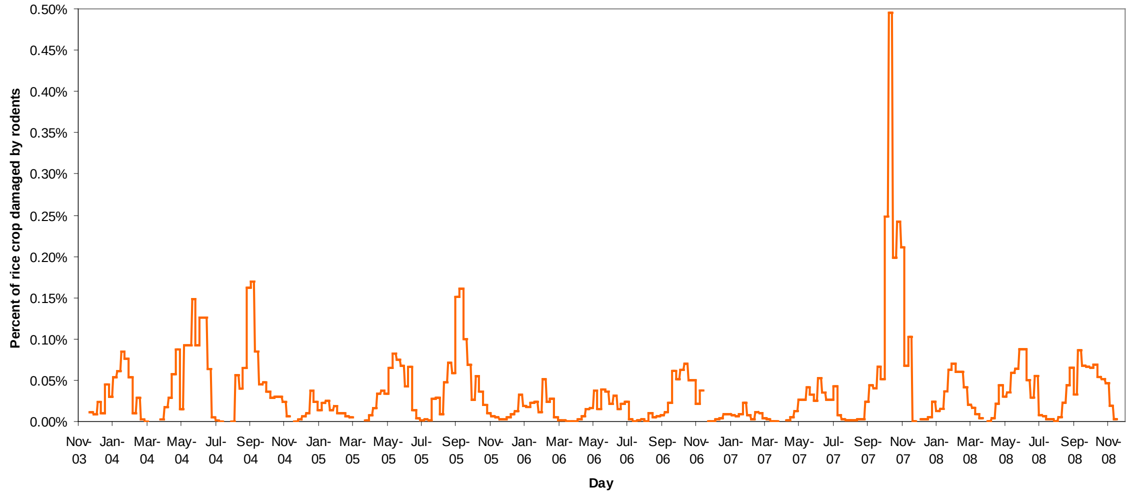


Figure 7.17. Daily fresh instantaneous rat damage calculated from weekly instantaneous damage as a percentage of area of rice crop grown each season.

Summary

Rodent damage to rice crops occurred throughout all phases of crop growth, but it appeared that damage started at a low level, then increased to a peak level during the middle stages of rice crop growth, then declined as the crop matured. This is consistent with the ecology of rodents in rice fields and the energy requirements of rodents, particularly for *Rattus argentiventer*, the key rodent pest in the lowland irrigated rice system.

As the rodents commence their breeding season, typically at late tillering stage (approximately 4 weeks after sowing of the rice crop; Brown et al. 2005*; Tristiani et al. 1998; Leung et al. 1999), adult females require large quantities of high quality food. This is when a peak in feeding activity on the rice plants occurred (instantaneous fresh damage). As rice crops mature (through booting and flowering stages) and grains begin to develop, rats need to consume fewer rice plants or tillers to achieve their energy demands resulting in a reduction in the intensity of feeding on the rice plants (instantaneous fresh damage).

The estimated level of damage to rice crops was lowest in the first rice crop (DX1), then slightly higher in the second rice crop (HT2) and highest in the third rice crop (Vu3). Again, this is expected from the ecology of the rodent populations. In areas where there are only two rice crops per year in Indonesia and Vietnam, the levels of damage and yield loss were always higher in the second rice crop (Singleton et al. 2005; Brown et al. 2006).

7.5.5 Rice crop modelling

The APSIM rice crop model was benchmarked with farmer yields in An Giang (Figure 7.18). The APSIM modelled yields were slightly higher than that observed on farmers fields, with yields 0.3% higher for the DX1 rice crop and 1.1% higher for the HT2 rice crop. Slightly higher yields are expected from modelled systems because they more closely reflects potential yields (without the impact of insect pests etc).

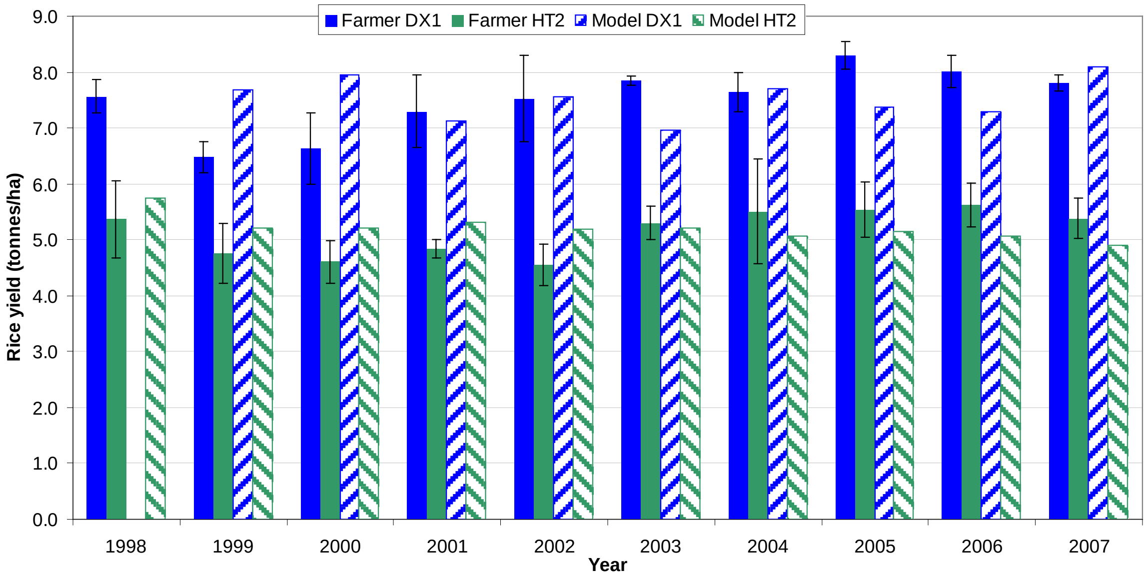


Figure 7.18. Yields from farmers (n=5) in An Giang province benchmarked against yields generated by APSIM for the 1st (DX1) and 2nd (HT2) rice crops, from 1998 to 2007.

The APSIM model was further validated by comparing the yields from My Phung's rice clipping experiment that was conducted in rice fields in An Giang with the APSIM model results (Figure 7.19). There was general agreement between the modelled output and the field observations to warrant further development and refinement of the APSIM model to look at the effect of rodent damage on rice yields. The general shape of the response was captured, which was sufficient to further develop the model and incorporate the damage data available from the An Giang Plant Protection Department (Brown & My Phung In Press).

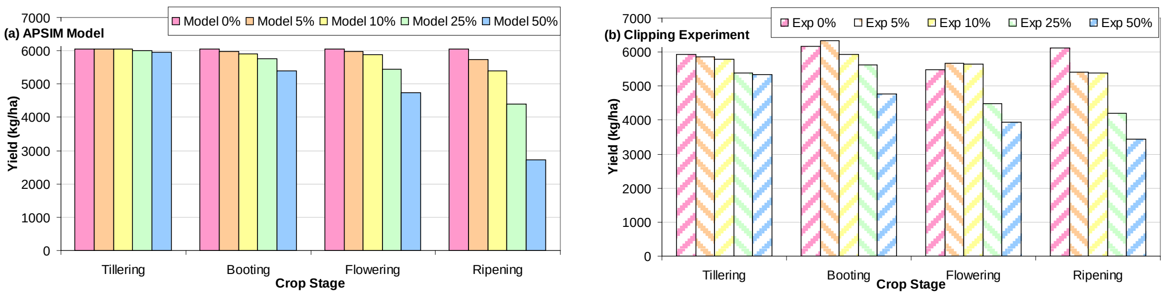


Figure 7.19. Yields of rice from the (a) APSIM model and the (b) clipping experiment (kg/ha). Data for (b) from My Phung et al. (In Press).

The Excel model was constructed so that any combination of control effect and timing of control could be applied to effectively reduce the rodent damage to the rice crop. The basic model in Excel was constructed so that a visual description of the impact of rodent damage could be compared against a "no control" situation (Figure 7.20). Control could be applied at any stage throughout the three rice crops and at any intensity. An ideal "daily" rodent control was run to examine the response of an ideal rodent control strategy where rodent control could be applied every day up to 100% effectiveness (up 100% reduction in rodent damage effect). This was valuable because it established a "gold standard" in what could be achieved with rodent management, and so all other combinations of rodent control were then compared to that. Rice yields from the APSIM model could then be compared.

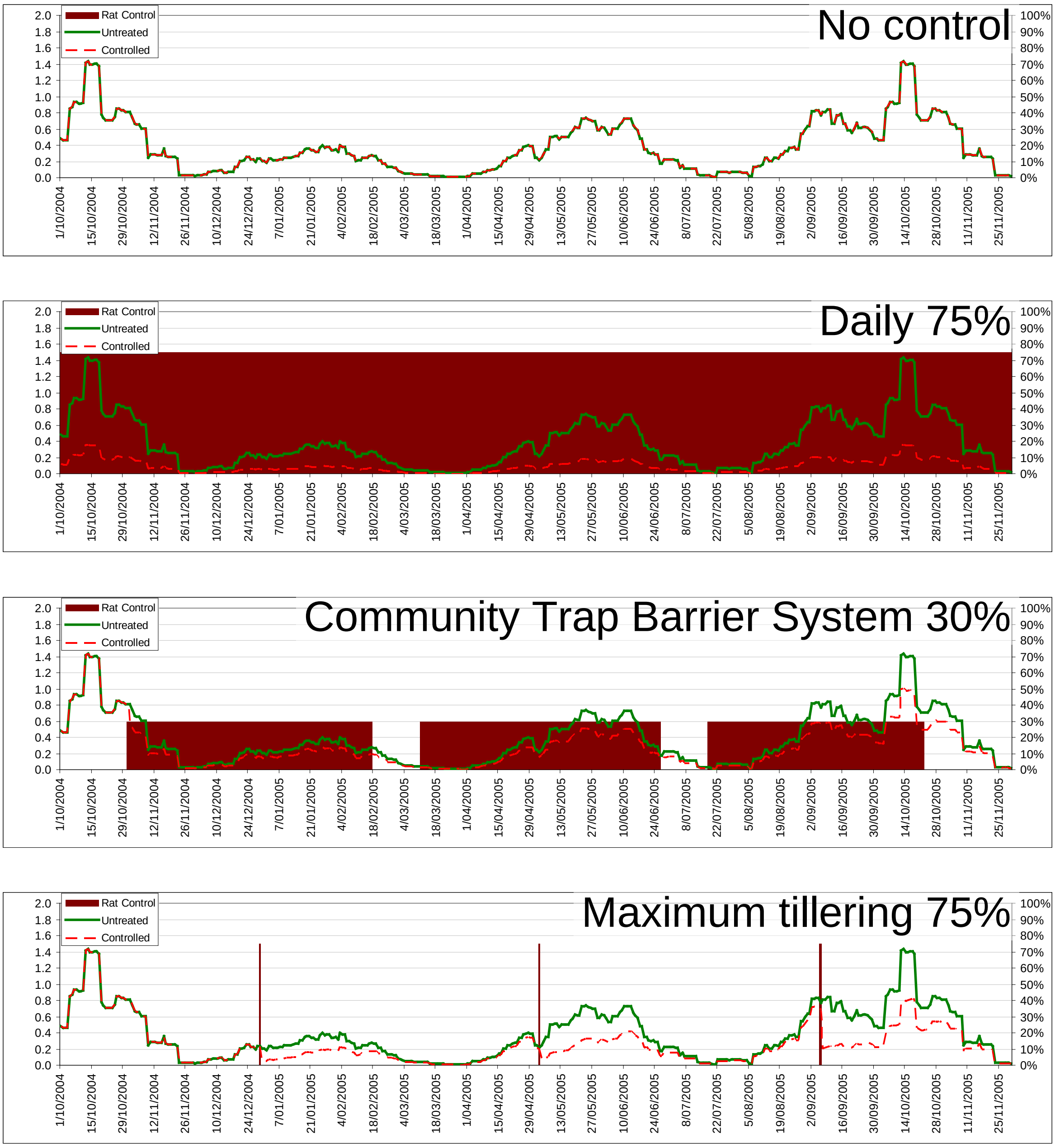
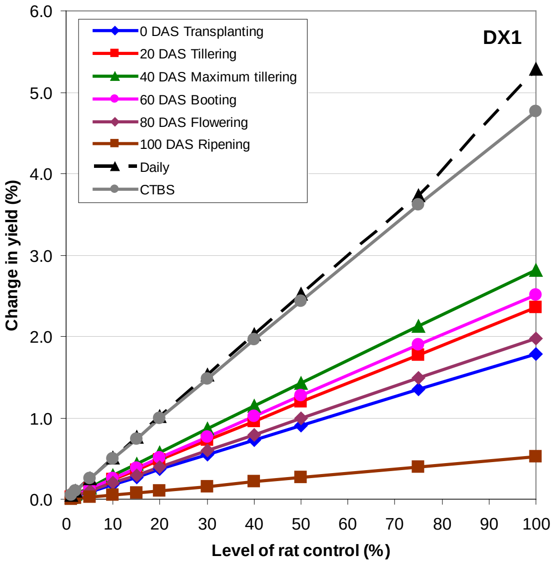


Figure 7.20. Examples of the different types of rodent control that could be applied to the rodent damage using the Excel spreadsheet. Left axis is a measure of rodent feeding damage on the rice crops, the right axis is the level of control applied and the x-axis is the daily time-steps. (a) no control was applied (the untreated and controlled damage was the same), (b) control was applied at 75% every day throughout the year, (c) a CTBS was established and achieved a 30% reduction in rodent damage, and (d) control was applied at maximum tillering stage at an intensity of 75%.

All combinations of the timing of rodent control on rodent damage and intensity of effect were collated and summarised for each of the three main rice crops for An Giang (DX1, HT2 and Vu3) (Figure 7.21). These graphs show how rice crops are able to compensate for rodent damage, and particularly, to show the level of rodent control necessary to achieve a 5% increase in rice yields. For example, in the DX1 crop season, only sustained rodent control of 100% every day - which is unrealistic - would achieve a 5% yield increase.



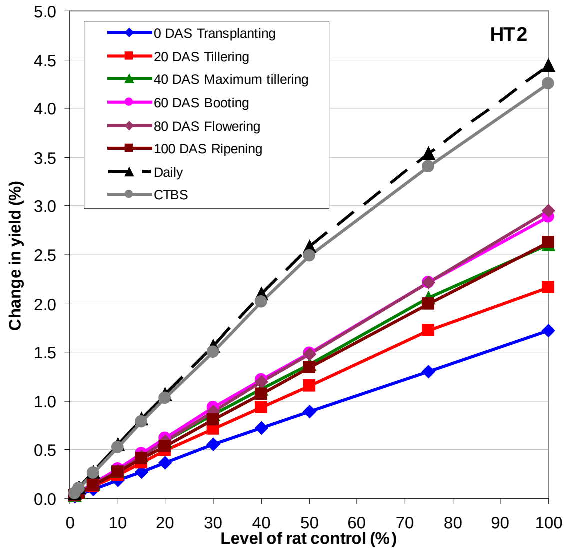
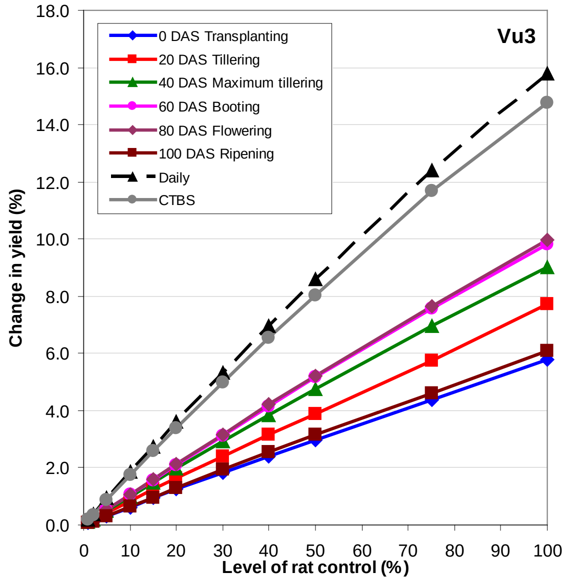


Figure 7.21. Response of rice crops to reduction in levels of rodent damage to rice crops at varying intensities (x-axis) and varying stages of crop growth (different lines) for the three rice crops (DX1, HT2 & Vu3) grown in An Giang, Vietnam.



Since the level of yield loss generally increased through DX1 to HT2 and was highest in the Vu3 crop season, it is worth examining the response of the rice crop to reduced rodent damage in the Vu3 rice crop season. In the Vu3 crop season, a 5% yield increase was achieved with the use of the CTBS with a 30% level of control effectiveness (Figure 7.21c). Furthermore, a 5% yield increase was achieved at booting stage with 50% effectiveness and flowering stage with 50% effectiveness.

This means that control applied at the flowering stage or booting stage were equally effective in reducing damage and therefore increasing rice yields. Based on this, and based on the assumption that rodent control should be applied early during the growth of the rice crop before breeding commences in the rodent population, rodent control should preferentially be applied at the booting stage.

The basic results from this modelling were incorporated into the integrative model (Section 7.5.1) and the project's economic model (Section 7.5.3).

7.6 General discussion and summary

There was a strong and sustained effort to encourage farmers to participate in EBRM strategies. This started out at a small scale in a few "Treatment" villages in the first year of the project (2006). The treatments implemented were slightly different according to the countries and regions involved, but were essentially a combination of Community Actions alone or in combination with CTBS.

Initial training focussed on a "Training-of-trainers" (TOT) approach where regional extension staff were trained in basic rodent biology, ecology, taxonomy and exposed to a range of rodent control strategies that would be implemented by farmers. These training sessions were followed up with in-depth training with farmers in "Treatment" villages. This training involved some hands-on practical training (eg: how to build a CTBS or how to run a community campaign with other farmers), plus setting up a range of demonstration sites and handing out brochures and other training materials. Training and follow-up visits occurred prior to planting of crops, and perhaps once or twice more during the growth of the rice crop. Tens to hundreds of farmers were trained in each of the "Treatment" sites.

Over subsequent years, the focus of working with farmers shifted to neighbouring villages and other areas. The training, demonstration sites and other activities largely followed the same process. The training and follow-up were not as intensive, but the scope dramatically increased with each season and year, such that around 10,000 farmers in all ten Districts of Karawang (West Java, Indonesia) and more than 8,000 farmers in 11 Districts of An Giang (Mekong River Delta, Vietnam) had received training and were conducting EBRM.

Over the course of the project in Indonesia, higher rice yields were observed in West Java, with a 5% increase on areas where EBRM were practiced compared to nearby areas where no EBRM was implemented. Given rodent damage generally results in yield losses of 10-15%, this project has delivered a significant 33-50% reduction of yield loss leading to 2-5% yield increases. This occurred over and above what farmers were already doing to manage rodents in areas where EBRM was not implemented - that is, farmers were still applying rodenticides, fumigating, digging burrows etc. The application of EBRM replaces conventional rodent management by applying management over large areas and early in the crop cycle so as to reduce the number of rats in the field before they can cause significant damage to crops.

A significant component of farmer training was the integration of modules of EBRM into national training programs, such as the "3-reductions, 3-gains" program in the Mekong River Delta, and the ICM Farmer Field School, P2BN, Primatani, and IPM training in Indonesia. This embedded EBRM into the national programs to ensure the sustainability of training for rodent management, but also exposed a large number of farmers to EBRM training in a range of other areas. As a simple measure of success of these national programs as well as the communication strategy, there were observable reductions in the levels or area of rodent damage in both Vietnam and Indonesia and an increase in rice yields (see Figure 7.1 and Figure 7.2 respectively).

Farmers in both Vietnam and Indonesia were certainly aware that rodents caused significant damage to crops and that they needed be controlled effectively to increase rice yields. A baseline survey of farmers found that much of the rodent control effort was implemented at a time when significant damage to rice plants was occurring. Furthermore, farmers traditionally used a range of practices to manage rats, but these were often conducted individually and in an uncoordinated manner. Farmers recognised that rodenticides were not safe for humans or other animals or the environment, yet rodenticides were an important technique for rodent control. Despite relatively high rates of participation and membership of farmer groups or organisations, they were not used as major sources of information about new farming technologies. The agents that farmers relied on most heavily about new farming technologies were farm neighbours, relatives and agricultural extension staff. Traditional forms of mass media (TV, pamphlet, bulletin, newspaper, radio) were not influential for disseminating information about agricultural practices. Overall, the levels of social unity were slightly different among West Java and South Sulawesi in Indonesia. Despite this, farmers had strong beliefs that Community Action was necessary to control damage. In Vietnam, there were strong and coordinated links between local political and extension institutions

The adoption of CTBS was almost none through the project. It was only practiced in the pilot sites involved in Vietnam and Indonesia. The constraints reported by farmers were high material costs and time requirements. Conversely, Community Actions were used widely. In many areas, they were conducted three to four times a season, particularly in early stages of rice crop growth (eg land preparation, just after planting up to tillering stage). Community participation came from farmers, household members, members of village associations, and in Vietnam was organised through the Plant Protection Stations in collaboration with the village People's Committees.

A range of diffusion pathways were used in Vietnam, through TV (local and national), radio broadcasting (province, district, commune, and village), training of trainers to provincial staff in a number of provinces, and farmer training and implementation of Community Action. As highlighted, many of the broadcast media communication strategies were not influential in farmers' decisions, but the training of extension staff, word-of-mouth and demonstration sites were highly effective.

The assessment of diffusion of EBRM in Ha Nam Province, showed that farmers had watched some of the segments on Vietnamese TV and were aware of the articles in the local newspapers. Some farmers had heard of the CTBS, but because of high investment costs and technical constraints (early planting), none of the farmers had established their own CTBS, except for those in the demonstration fields. This suggests the value of observation and demonstration sites for uptake and adoption of technologies. In addition, farmers perceived that the rat population was too low to justify investing in a CTBS.

Community Actions were taken up by farmers in neighbouring villages and neighbouring provinces. The effective pathway for EBRM implementation in northern Vietnam was through the strong, coordinated linkages between the local political and extension institutions. Furthermore, farmers' cooperatives are the key vehicle for organising and mobilising farmers' participation and rodent control group for Community Action. The People’s Committee provides the political and financial support to farmers' cooperatives. At times, the PPD provides financial support through the department of agriculture via farm demonstrations, training and field days.

The Key Informant Interviews conducted in Indonesia yielded strong messages about the importance of coordination among civic and government stakeholders. Coordinated farmer cooperation is necessary for the implementation of EBRM but if there is a layer of disjointed governance, then community rat management is hampered. Disjointed governance was pinpointed as an EBRM barrier for several issues: whether spatial patterns of rat damage and agency attention could be overcome; whether the financial requirements to make a technology work could be met; whether effective incentives and penalties could be devised, and whether farmer groups functioned at their most effective. Furthermore, the more complex the EBRM technology, the larger the demands upon coordination among and between civic and government stakeholders are necessary to make it work. This was one of the key drivers as to why the CTBS technology was not adopted more widely. Conversely, since the Community Actions technology was relatively simple, it was more easily adopted.

There were issues raised by farmers about gaining permission from land owners to participate in community-based rodent management, especially with absentee landowners. This is affected by the proximity and incursion of large urban areas. Proximity to urban areas also influences the amount of public money available for EBRM. Also the issue of conversion of agricultural land for urbanisation.

Community based rat management is highly dependent upon strong, effective leadership of farmer groups. Ideally, they work in partnership with agricultural agencies to access outside resources in a manner that met both agency and local goals.

The modelling components of the project were conducted to better understand some of the decision points that farmers need to make and to explore some of the levers that can influence farmer behaviour by exploring a range of scenarios of possible management strategies, and their impacts on rat damage, rice yield and ultimately on farmer livelihoods. The modelling was framed around trying to understand the livelihoods options and aspirations (or utility function) available for farming households; for example, is the purpose of improved rodent management to increase money or time available for other activities.

The integrative model was designed as a tool to support communication of important drivers of successful rodent control, to explore a visual display of the net effects of rodent management on crop productivity, considering rodent populations, rice production and farmer activities. This was done to represent some of the system-level outcomes that cannot be achieved by the separate models themselves to identify the best set of strategies for the system as a whole to optimise for profit or time.

Participatory workshops with government staff and extension staff clearly showed that such a model would be useful to work with farmers to demonstrate some of the complex interactions and dynamics of community rodent management. Further work was planned to finalise, validate and simplify the graphical interface of the model and to translate it into Vietnamese and Indonesian, however, supplementary funding was not available.

The economic modelling demonstrated how Community Actions and CTBS can be successfully implemented to gain significant community benefits from increased yields and lower aggregated costs. A statistical cluster analysis separated out two Farm Types, smaller blocks of land (2.5 ha) and larger blocks of land (5.1 ha). Decisions about which rodent control methods to use were based on community participation and control intensity (effectiveness), and optimal participation and intensity levels were calculated. In the third harvesting season when rodent damage was generally highest and rodent control led to improved yields, CTBS was only recommended when 50-60% of the farmers could participate, otherwise Community Actions were generally sufficient.

We successfully built a simple rodent population model which provided flexible in examining the impact of various rodent management strategies on rodent population abundance. This was then built into a rat damage model, which was built on five years of damage data collected in An Giang Province.

The APSIM rice crop model was benchmarked against farmer's yields, then validated against a clipping study conducted as part of My Phung's PhD field study. By incorporating the dynamics of how a rodent population responds to control and the damage relationships, a range of rodent management strategies were explored to ascertain the impact of rodent control on reducing levels of rodent damage and comparing impacts on increased rice yields. A range of scenarios were run and compared to a "gold standard" of controlling 100% of the rat damage every day throughout the year. Based on these, and based on the assumption that rodent control should be applied early during the growth of the rice crop before breeding commences in the rodent population, rodent control should preferentially be applied at the booting stage.

Key drivers of successful EBRM

These findings can be considered for future delivery of successful EBRM in lowland irrigated rice cropping systems in Vietnam and Indonesia. These are based on the following points:

- Integrate EBRM training modules into national farmer training programs and follow a "training-of-trainers" (TOT) approach;

- Identify social, economic, institutional and physical barriers to effective extension;
- Farmers get most of their information from talking with other farmers and from observing or being involved in successful trials or demonstrations;
- Adoption depends on the attributes of management practices (simple technology is more likely to be adopted), the aspirations of households, and the capacity of rural households;
- Adoption requires effective support within village leaders and village champions, within regional government & institutions and from national governments.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The aim of this project was to expand the use of ecologically-based rodent management (EBRM), an approach that was field tested at the village level in the previously-funded ACIAR rodent project (AS1/1998/036). The current project (ADP/2003/060) has confirmed the utility and robustness of EBRM as an approach to manage rodents in lowland irrigated rice cropping systems. It was clearly used within our target communities on treatment sites early in the project, but then expanded into other sites (control or reference sites and to neighbouring sites over time).

It has also refined the key recommendations for managing rodents. A key focus is to employ rodent management over large areas early in the rice crop growth phase - this has not changed, but there has been confirmation that in most years the Community Actions would be sufficient to manage the rodent problem without having to use the CTBS. The CTBS has still proved to be a useful and efficient management strategy in its own right, but there are a number of issues that mean it is less tractable for farmers than the Community Actions are. The overall utility of EBRM as a concept has been strengthened through this project.

The concept of EBRM is now more widely known throughout the world and is being used in increasingly more situations and circumstances. There are three key areas where our work has led to changes in how scientific practices have changed outside the project because of the findings of this project:

1. There was a very high profile of EBRM at the 3rd ICRBM (Hanoi, Vietnam 2007) and at the 4th ICRBM (Bloemfontein, South Africa 2010). At the 4th ICRBM, there were 6 plenary speakers, 99 spoken papers and about 50 posters. There were 16 oral papers and 4 posters that directly used the concept of EBRM outside our project, and 7 oral presentations and 3 posters directly from the project. Given the wide range of symposia at the conference, this represents a significant impact and success of the concept of EBRM that has grown out of the ACIAR-funded rodent work over the years.
2. The ECORAT project in southern Africa ("Development of Ecologically-Based Rodent Management for the Southern African Region"; Southern Africa Development Community, SADC, funded) - is based on the philosophy behind EBRM (URL: http://www.nri.org.projects/ecorat/) (Belmain et al. 2010). This is effectively a "sister" project to this ACIAR project. Dr Grant Singleton (IRRI) and Dr Peter Brown (CSIRO) are on the international advisory board and have attended the annual meetings in Swaziland in 2007, Tanzania in 2008 and Namibia in 2009. This project has demonstrated the influence of our ACIAR rodent work on equivalent work in Africa to manage a different suite of rodent pests in different agro-ecosystems.
3. As mentioned in point 1, there is now active research in a wide range of circumstances where the concept of EBRM is being tested and used to manage rodent problems. These include managing voles in Germany, managing sewer rats in Denmark, managing rodents in millet in Namibia, managing rodents in maize systems in Tanzania and Swaziland, managing rodent outbreaks in Bangladesh, India, Myanmar, Laos and the Philippines, and in post-harvest situations in Bangladesh and southern Africa. This also flows on from work conducted on managing mouse plagues in Australia.

Another significant impact has been through the development of multi-disciplinary teams and multi-disciplinary approaches, particularly relating to the socio-economic components of the project (economic models, cropping models, rodent population dynamics models and integrative models) and examination of the diffusion and adoption of sustainable EBRM strategies.

Over the next five years, it is anticipated that there will be two main scientific impacts as a legacy of this project:

1. *Publications from this project*: We have already published 20 papers from this project (see Section 10.2). We are endeavouring to publish at least another five papers directly from this project and a number of ancillary papers. The five papers are likely to be published as part of the proceedings from the 4th ICRBM. We will be contributing to a special issue of *Wildlife Research*, an internationally recognised journal for wildlife management and a key target journal for our research. The papers will be part of a section on the socio-economic considerations for rodent management and we have recently received confirmation from the conference organisers that our papers will be considered. The papers that will be submitted are:

   - Brown, P.R. and My Phung, N.T. – Rats in rice; models to explore management strategies;
   - Fletcher, C.S., Brown, P.R., van Grieken, M., Sudarmaji, Baco, D., Huan, N.H., and My Phung, N.T. - Integrating social, economic and ecological models of community rodent control in Southeast Asia;
   - van Grieken, M., Roebeling, P.C., Zull, A. and Brown, P.R. - Economic impacts of integrated rodent management strategies; and
   - van Wensveen, M., Brown, P.R., Sudarmaji, Razak, N., Baco, D., Anggara, A.W. - Knowledge, attitudes and practices for rodent management in South Sulawesi and West Java, Indonesia.

   Another paper ready for submission is:

   - Darbas, T. - Agricultural governance: a comparison of uptake of ecologically-based rodent management by rice farming communities in two Indonesian regions.

   Another seven papers are nearly ready for submission (see Section 10.2.4). In addition, there will be a number of papers derived from the John Allwright Fellowship MSc and PhD students associated with this project. This and the general culture for publication of research work demonstrate a clear desire and practice for delivering research to scientific publications. This enables our work to be peer reviewed in the international scientific literature and strengthens our contention that this type of work is of high quality science (through rigorous scientific research).

2. *Development and refinement of EBRM*: Our work has enabled us to share our experiences and approach to EBRM (through presentations at international conferences, international journal papers etc), such that the research partners in this project are considered international leaders in the development and testing of EBRM in the world.

8.2 Capacity impacts – now and in 5 years

Much of the emphasis of this project has been training key staff who operate with farmers on the ground to 1) ensure adoption and implementation of EBRM, 2) strengthen the network of support staff to ensure sustainability of the work, and 3) embed project approach and principles into existing or developing institutional arrangements.

Through project activities there has been a wide range of training and capacity building opportunities for scientific staff, project staff and extension staff. A mix of formal and informal training opportunities has been utilised.

8.2.1 Formal degree and course training

There has been a strong emphasis on the formal degree training of staff involved in the project, particularly from Vietnam. There have been three in-country staff that have taken opportunities with John Allwright Fellowships to conduct MSc or PhD research studies in Australia, linked with the project:

- Mr Le Anh Tuan (World Vision Vietnam) - has completed his MSc at the School of Earth and Environmental Studies, James Cook University, Townsville. He submitted his thesis in March 2009. The topic of the thesis was: “Socio-economic constraints to rice farmers’ adoption of the community trap barrier system for controlling rodents in rice-based farming systems in the Mekong Delta, Vietnam.”
- Ms Nguyen Thi My Phung (An Giang PPD, Vietnam) - enrolled as a PhD student at the University of Queensland (Gatton Campus) on the project "Action-based research for rodent management in mixed cropping systems - bridging the research-extension divide". From her research, she has 2 papers submitted for publication (My Phung et al In Press, Brown & My Phung In Press) and she recently won the prize for the best student presentation at the 4th ICRBM at Bloemfontein, South Africa in April 2010.
- Mr Tran Thanh Tung (PPD, Vietnam) - enrolled as a PhD student at the Australian National University and CSIRO Entomology (Canberra) on the project "Effects of plant extracts and chemical on fertility control of rodents" commenced in August 2008.
- Mr Muslimin (ICRR, Indonesia) received scholarship for PhD training at Bogor University (started November 2006).
- Mr Bastian is completing his MSc degree in Wageningen University in Social Science in rodent management in Pinrang (South Sulawesi).
- Ms Nur ‘Aini Herawati (MSc based at ICRR) received a scholarship from the Indonesian government for pursuing her PhD in Gadjah Mada University in Yogyakarta. Her study commenced in September 2008. She will focus on reproduction of rodents for her thesis.
- Ms Sabrina Samson (Wageningen University, Netherlands) conducted a 6 month Occupational Traineeship with Dr Peter Roebeling (CSIRO) based in Townsville. The topic of thesis was “Characterisation and classification of farm households in irrigated rice production in the Mekong Delta in Vietnam.”
- Ms Aurelie Delisle conducted a 6 month studentship with Dr Peter Roebeling (CSIRO) based in Townsville to assist Ms Samson and Dr Roebeling in characterising the farm household data from the Red River Delta, Vietnam.

Another avenue for training opportunities has been through formal training courses - project staff have taken opportunities to gain further training in a number of areas:

- Mr Agus Wahyana Anggara (ICRR) participated at the IRRI training course “Ecological management of rodents, weeds and rice diseases – biological and social dimensions” (March 2009). Funding was provided by ACIAR and ICRR.
- Ms Nguyen Thi My Phung (An Giang PPD) participated at the IRRI training course “Ecological management of rodents, weeds and rice diseases – biological and social dimensions” (March 2009). Funding was provided by ACIAR and CSIRO (Agricultural Sustainability Initiative Theme).

8.2.2 Formal project training

There have been a range of organised "formal" training courses designed and run as part of this project. The target for these training courses were project staff and extension staff, but also farmers have benefited from this directly or indirectly.

- KAP&SE survey training for project staff (provided by CSIRO and IRRI 2006). This was done both in Vietnam (Ha Nam and An Giang provinces) and Indonesia (West Java and South Sulawesi provinces).
- Data Editing and Management training course in West Java (2 staff) and South Sulawesi (3 staff) in June 2007 (conducted by IRRI).
- IRRI ran some follow-up training workshops (2008) on data collection techniques for the KAP&SE ex-post survey. This training also included data entry techniques. Project staff were keen to further develop their skills to broaden their experience in terms of analysing data.
- Training courses were run on rodent biology, taxonomy and management (eg trainers of trainers (TOT), link into FFS, Primatani etc) (An Giang Sep 2007; Ha Nam June 2007) (provided by PPD and NIPP and IAS). This led to further training courses that were run and organised by extension staff based on the course content of the formal training courses.
  - Training of technical staff in Ha Nam and An Giang (plus other provinces outside the target provinces) (50 technical staff). Additional training has been coordinated through World Vision (25 staff).
  - Two day training course on rodent biology, taxonomy and management, South Sulawesi, Indonesia, August 2007. There were 22 people in attendance, primarily from the South Sulawesi (farmers, extension staff etc) from Makassar, Sidrap, Pinrang and Enrekan districts. This included four people from Southeast Sulawesi (3 staff and 1 farmer from Kendari), supported by another project (through Dr Peter Horne, ACIAR/SMAR SADI). The resource people were Dr Peter Brown (CSIRO), Dr Grant Singleton (IRRI), Dr Sudarmaji and Ms Nur Aini Herawati, (ICRR, West Java) and Mr Djafar Baco (BTPT, Maros, South Sulawesi).
  - Ecological rodent management technology training for farmers (provided by An Giang and Ha Nam Sub-PPD) (An Giang: Tri Ton: Nov 2007, Dec 2007; Tinh Bien: Nov 2007 (2x), Dec 2007; Chau Phu: Dec 2007; Long Xuyen: Dec 2007; Thoai Son: Dec 2007; Chau Thanh: Dec 2007). Ha Nam: Feb 2008, Ngoc Son: Feb 2008; Binh Minh: Feb 2008; Mai Luong: Feb 2008; Bac Son: Feb 2008; Nam Son: Feb 2008).
  - Ecological rodent management training was conducted on project sites, but also in other neighbouring districts within target provinces and reached >270 farmer participants in Vietnam.
  - In West Java in 2008, follow-up training was conducted with farmers in the treatment villages. Intensive supervision of farmer activities by extension staff was conducted to check rat control activities in each village. Additional rodent management training was conducted in June 2008, which involving AIAT, extension staff, local government employees, and farmer groups from the village joining “EBRM scaling out” program.
  - ICRR conducted training for villages outside core project areas in 2008 and included ICRR, AIAT, Dinas Pertanian – Karawang as partners. There were 40 participants: farmer groups (Gapoktan), extension officers, researchers and representative of house wives from Citarik village.
  - ICRR also conducted training of extension workers from neighbouring districts (Karawang) surrounding the core project sites in West Java. There were 5 staff, and an additional 3 new women extension workers that just completed their graduation from university (agriculture degrees).

- At the national level in Indonesia in 2008, ICRR were involved in training sessions in South Sulawesi, South-East Sulawesi, South Sumatera, Bengkulu, Central Java, and West Java. These involved farmer groups, researchers (AIAT), extensionists (DINAS), and local government officials. Other training at ICRR involved: ICM Farmer Field Schools, P2BN, Primatani, and IPM training.
- In South Sulawesi, 30 extension workers from several subdistricts were trained in December 2008. The training was conducted at BPP Teppo and Primatani Leppangan. There were also strong links to other projects of BPTP and Dinas at province and district level. It was emphasised that further training is required, especially at field days. It was suggested that at every meeting of agriculture in Pinrang, ecologically-based rodent management must be included.
- Development of training modules and resources in-country (including manuals, brochures etc). Unfortunately, the Indonesian rodent manual was not completed. It was hoped that this could be resources through additional funding from ACIAR as indicated as a Recommendation from the Review of the project held in May 2009.

[insert summary table of dates and numbers of project staff, TOT, project farmers and non-project farmers.]

8.2.3 Informal training

There have been a range of informal and "on-the-job" training opportunities, particularly for project staff involved in the project. For example, we have encouraged young staff to give presentations at the annual project coordination meetings to give them exposure to presenting to an audience, preparing PowerPoint presentations and also to present in English, but in a friendly and relaxed setting.

- Regular training with farmers on CA and CTBS. There were 4 training courses for farmers during the winter cropping season, and another 2 training courses in the following season. 20-25 farmers attended each course.
- In March-April 2008, one staff from ICRR Rodent Laboratory (Ms Nur ‘Aini Herawati, MSc) visited South Sulawesi to assist Dr Toni Darbas (CSIRO) for doing key informant interviews i.e. local government staff, extensions in sub-district and district level, community leader as well as active farmers were interviewed in Leppangang, and Marranu. This was a great opportunity for staff from different institutions (South Sulawesi AIAT and ICRR) to share experiences and challenges for implementing EBRM in their geographical and cultural environments.
- Training of project staff through on-the-job training, including formal Microsoft Access training as part of the data entry and verification process for the KAP&SE data in both Vietnam and Indonesia (conducted by IRRI).

Likely impacts in 5 years

There is a strong likelihood that these training activities will have benefit for individuals and institutions in the future, particularly as they more opportunities may arise. This will be particularly true for the formal degree training being undertaken by in-country project staff. In all cases, they will return to their institutes and have a significant impact on the work they do, leading to better outcomes for their institutions.

Furthermore, this project has improved the capacity and knowledge of staff to shape rodent management not only in their own institutions, but also for their provinces and possibly nationally, and has created (or at least maintained) strong national and regional networks.

Another strong impact will be the embedding of training modules for rodents into national curriculums for crop management and for other pests (eg "3-reductions, 3-gain" in Vietnam; Primatani, ICM, IP Padi 400 & P2BN in Indonesia). This will ensure the sustainability of rodent management, but also significantly increase the number of farmers exposed and area of farmers exposed to EBRM training to rodent management principles and effective community management approaches over the forthcoming years.

8.3 Community impacts – now and in 5 years

The management of rats on a broad scale has been successful through the effective demonstration of the science of sustainable EBRM at a community scale. There has been effective use of Community Actions (CA) including synchronised cropping, field sanitation and mobilisation of community campaigns, and good captures of rats in CTBS.

Vietnam

- There is now more cohesive interaction among different sectors in the community in the project sites (farmers, farmer leaders, political leaders, youth, women, village security). The CA activities have now been regularly done in An Giang and Ha Nam treatment communities. The People's Committee are actively involved in An Giang, while it is the farmers' cooperative through the rodent control group in Ha Nam. There were a total of 480 farmers participating and participants in the project sites have realised their role in CA activities, to bring common benefit to the whole community - reduced rodent damage.
- The CA activities had a significant spill over benefit for the management of brown plant-hoppers (BPH), because synchronised cropping has the mutual benefit for management of rodents and the BPH.
- Inclusion of EBRM into a regional program on best practice for the sustainable production of rice crops in the Mekong River Delta.
- There was agreement at the project planning workshop in An Giang in April 2008 that the national curriculum for rodent management needs to be updated and modified. This is linked to the Prime Ministers Directive (released in 1998 – and was strongly influenced by the previous ACIAR projects in Vietnam), and there is a desire amongst project participants to have this reviewed and updated for approval through the National Committee for rodent control (PDD is the executive secretary in Hanoi).
- Training activities in Ha Nam have been linked to the IPM farmer training of 1,770 farmers.
- Farmers' knowledge about rat biology and management has been significantly improved.
- Preliminary results from the KAP&SE ex-post survey indicate that farmers are now managing their rodent problem through group or community activities. For example, from the KAP&SE ex-ante survey, 90% of farmers conducted rodent management activities individually, 32% used group actions and 36% used Community Actions. From the KAP&SE ex-post survey, 57% of farmers conducted rodent management activities individually, 44% used group and 62% used Community Actions. This is a substantial decrease in individual actions and an increase in group and Community Actions and demonstrates the overarching concept of EBRM to manage rodents at a community level, indicating that training and communication strategies have been successful.
- The successful implementation of rodent management strategies (CA and CTBS) is attributed to the joint effort of many institutions and their staff, leaders and farmers, including PPD, Sub-PPD, Plant Protection Stations, People's Committees, village extension staff, farmers' associations, cooperatives, youth union, women's group and village rodent control groups.

- The strong leadership of the farmers' cooperatives in Ha Nam enabled the successful implementation of rodent management interventions. This is assisted by a well organised rodent control group or plant protection team to spearhead the Community Action activities.

Indonesia

- Sustainable adoption of EBRM in Indonesia through its integration into agricultural business model demonstrations at Primatani sites in South Sulawesi, South Sumatra and West Java. The project is integrated with the national Primatani program that aims to increase agricultural productivity with new technologies Key informant interviews indicate that local government funds could be used to purchase LTBS materials if the farmer group members requested it.
- In West Java, during the first planting season of 2008, EBRM activities involved neighbouring villages. This demonstrates the diffusion of EBRM into neighbouring areas.
- CTBS is still being used to protect nursery beds. In West Java, farmers are working together to manage their seedbeds through using plastic barriers around their rice nurseries to protect them from early damage. There is no need to use traps because of the success of Community Actions.
- Mass campaigns against rodents are still being organised, but fewer rats are captured. Farmers are happy, because they are realising the benefits of the community approach to rodent management. This is an example of successful strategies leading to reductions in yield loss and improved yields. Many of these activities have relied on the community working together across their fields at key times using a range of actions including digging burrows, hunting, fumigation, flooding burrows with water.
- Farmers are making decisions and then sharing the cost for the use of LTBS within their villages. Farmers are getting additional financial support from the village and district and then design a program for the use of the LTBS around their village.

Likely impacts in 5 years

We anticipate that much of the potential community impact in five years will be through the further development and expansion of Community Actions for controlling rodents. This will largely be attributed through the incorporation of the methodology for Community Action in the national programs for rodent management and crop management programs in both Vietnam ("3 reductions, 3-gains") and Indonesia (Primatani, ICM, IP Padi 400 & P2BN).

8.3.1 Economic impacts

The economic benefits of conducting EBRM are becoming clearer. From field observations in both Vietnam and Indonesia, rodent management is becoming less expensive while becoming more effective leading to higher yields and increased livelihoods and food security.

We have good evidence from the modelling studies that show how Community Actions can significantly reduce rodent damage provided action is conducted relatively early and over a large area and involving the community. Reductions in yield losses and improvements in yields should be easy to achieve. Despite the obvious and recognised upfront establishment costs for CTBS, it still remains a viable and effective method for rodent management, particularly in seasons where rodent numbers are likely to be high, but requires some community coordination and access to fields and water resources to plant the early crops. Community Actions remain the key approach for EBRM in nearly all situations.

Vietnam

- The economic benefit of implementing EBRM on treatment sites (CTBS or CA) led to yield increases of 0.9% to 1.9%. However, the economic impact has not been fully analysed yet.
- The use of CTBS has been reduced or eliminated during the spring rice crop in Ha Nam and the first rice crop after flooding in An Giang because rodent damage is low and it is difficult to set up the CTBS because of water availability and rice seeds. The CA activities have been considered sufficient to manage rodents during these seasons. CTBS remains successful in the other seasons.
- The benefit of implementation of CTBS and CA has been clearly proven with a sharp decrease in rice areas affected by rodents. The overall level of rat damage ranged from 7-16% during 2001 to 2005, but the level of rat damage since 2006 has decreased to less than 4% (some years less than 1%). This means greater rice yields and greater economic returns for farmers.
- The economic analysis conducted by Martijn van Grieken (CSIRO) shows that the economic benefits of implementing CTBS are high for farmers in An Giang even if they have a small farm area, compared to individual CTBS or current control actions. Further analysis is needed to investigate the impact of CA and other activities and to run the model in Ha Nam and sites in Indonesia.

Indonesia

- Rat damage in Citarik and Bojongsari (West Java) was less than 10% (typical year damage is around 15%) with an average yield of 5.5 tonnes/ha in the second planting season of 2007 (average usually around 5 t/ha).
- In Citarik and Bojongsari (West Java), there was a 5% increase in yields on treatment sites that implemented EBRM compared to other nearby sites that were conducting conventional rodent management practices (presented in Figure 7.2).
- Farmers have modified the multiple-capture traps that are used in LTBS and CTBS to make them cheaper.
- One farmer in Pinrang has started his own rat trap making industry to assist with effective management of rats in his village, but also to diversify his income.
- Farmers believe that because of the lower rat damage, they are getting higher yields.

Likely impacts in 5 years

The economic benefits of using Community Actions will become more evident over time as farmers continue to implement appropriate management at appropriate times and across appropriate scales.

8.3.2 Social impacts

Overall, there has been an increase in the involvement of the community for a common benefit. One of the key underlying principles of EBRM is to get the farming community to work together for rodent management so that management is conducted over a large area for cost efficacy and to minimise re-invasion.

Vietnam

- Increased social cohesion due to increased participation by farming communities – farmers, youth, community leaders, and women working together. There were 20 technical staff trained, plus an additional 200 technical staff. There are now 2,970 farmers inside and outside the project area that have been trained.

- Inclusion of EBRM into a regional program on best practice for the sustainable production of rice crops in the Mekong River delta. This will potentially give a spill over benefit for the management of BPH in the Mekong Delta region of southern Vietnam, because synchronised cropping has the mutual benefit for management of rodents and the BPH.
- In Ha Nam, the sense of community among farmers has been strengthened. For example, farmers attest that they look forward to community campaigns as they give them an opportunity to get together to catch rats, then share a meal, thus increasing the social cohesion of the community.
- Community organisations (Cooperatives, Farmers' Union, Women's Union) have motivated their members to actively participate in Community Actions and through different ways to catch rodents.
- The post-KAP survey is indicating that there is a switch from predominantly individually-based management actions to group or community based actions.

Indonesia

- Intensive community campaigns have been conducted in conjunction with neighbouring villages in West Java because of movements of rodents between villages. CA was conducted intensively in 6 villages, with a frequency of 7-10 times for every village. The total number of rats captured was 19,603 and involved more than 3,700 farmers. Intensive rat control activities were conducted to protect rice crop, and monitoring systems are now in place and communication between neighbouring villages is set up to avoid severe losses.
- Farmers are working together more now after the implementation of EBRM, whereas before most management was done individually.
- The Community Actions have enabled farmers to plan their community rodent management strategies and have provided a catalyst for discussions about a range of other issues.

Likely impacts in 5 years

Since one of the key principles for effective rodent management through EBRM is to encourage farmers to work together over large areas to minimise re-invasion, and since Community Actions seem to be one of the key sustainable approaches to rodent management, there is a good chance that this will continue to occur in the future. The social benefits for managing rodents, particularly in Vietnam are very strong, and it is also likely to be maintained in Indonesia also.

8.3.3 Environmental impacts

There are very strong benefits of applying successful rodent management on environmental grounds. Chief among these is the reduction in use of harmful chemicals to control rodents. Other harmful practices that have been reduced or eliminated as part of EBRM adoption are electrocution and pouring sump oil mixed with endosulfan across the surface of the rice paddy - these have serious environmental impacts.

Vietnam

- The use of CTBS and CA to manage rodents has not involved the use of chemicals. Captured rats have been buried – no environmental pollution took place. Since the commencement of the project, farmers have realised the environmental issues associated with chemical control. The reduced amount of rodenticides means that people are more willing to eat rats and there is a preference for live-caught rats. There was a 50% reduction in the number of farmers using rodenticides and a 90% reduction in the use of plastic fences to protect individual crops from rodent damage.
- Through effective CTBS and CA in Ha Nam, the perception of the farmers is that the ecology of the rice fields has been preserved.
- Use of rodenticide has been significantly reduced from 230-990 kg/year (up to 2005) to 92-144 kg/year from 2006-2009. This is a reduction of 62-90%.
- The use of electricity - a dangerous method in killing rats - has disappeared in project sites. It means that other animals or people are not harmed.

Indonesia

- There has been a strong focus on the use of Community Action for rodent management and the use of LTBS early in the cropping season, which precludes the need for other control practices (including rodenticides and fumigation) later in the crop growth.
- There has been a large reduction in the use of rodenticides. Fumigation is still used, but at more effective times (early in crop). Farmers are becoming more aware that rodenticides are harmful to the environment. This will be assessed once the post-implementation KAP&SE are available for Indonesia.
- Use of sump oil mixed with endosulfan has been significantly reduced on the study sites and is now only practiced in one small area.

Likely impacts in 5 years

It is likely that over time, the use of EBRM strategies will lead to an improved environment in the rice fields of Indonesia and Vietnam. The reduced use of rodenticides and toxic mix of other chemicals will mean that the predators of rodents are able to better survive in these environments and perhaps also provide ecosystem services to benefit farmers.

8.4 Communication and dissemination activities

There was a strong emphasis on communication and dissemination activities in this project as it was one of the key strategies to encourage adoption and implementation of EBRM through policy interactions, with extension staff, and ultimately within farming communities. There were a range of formal, informal, planned and serendipitous activities in both Vietnam and Indonesia, and more broadly.

The project team was unable to run final workshops in Vietnam and Indonesia to capture some of the key findings of the success or failures of the communication strategy and to capture observations from the diffusion study to develop a dissemination strategy. Furthermore, it was not possible to obtain resources to convene meetings with project staff and relevant government departments in Indonesia and Vietnam to prepare documents for policy makers. These were contingent on additional funding from ACIAR as recommended as part of the Review of the project that was held in May 2009. The project team still endorses this recommendation as an important activity for the future.

8.4.1 Interactions with policy

Vietnam

- Impact on National Policy. Dr Nguyen Huu Huan is part of the advisory Committee that is reconsidering the Prime Ministers Decree on rodent management for the country. It is anticipated that this will be updated based on the outcomes of this project.
- In Vietnam, EBRM has been integrated and mainstreamed into national training programs. This will ensure the sustainability of EBRM training technologies. The key National training initiatives was through the "3-reductions, 3-gains" program, targeted mainly at farmers in the Mekong River Delta region.
- Project start-up workshop (February 2006) to plan project activities in An Giang and Ha Nam provinces (Ho Chi Minh City, 25 participants). These included Directors of Provincial and national agencies.
- Visits to field sites to meet local government, farmers groups and farmers by IRRI and CSIRO project staff, for project site establishment (February 2006) and associated follow-up visits and meetings (June 2006, August-September 2006 and November 2006). These included Directors of Provincial and national agencies.

Indonesia

- In Indonesia, EBRM has been integrated and mainstreamed into national training programs. This will ensure the sustainability of EBRM training technologies. The four National training initiatives are:
  - Primitani – accelerate dissemination of agricultural production technologies;
  - Integrated Crop Management – 60,000 Farmer Field Schools;
  - P2BN – Policy initiative endorsed by President to increase rice production by 5%; and
  - IP Padi 400 – 4 crops/year initiative.
- ICRR had a very high profile during the Third National Rice Week, 21-26 July 2008. 35,000 people attended including the Indonesian President; >75% visited the ICRR rodent laboratory and its activities. There were seminars, indoor and outdoor demonstrations, demonstration plots for several innovative technologies in the field, business meetings interactive dialogue between researchers and stakeholders, and also thousands of visitors including farmers that will be attending the event. CTBS and LTBS were displayed in the field as part of the field demonstration.
- The adoption of project outputs by government with the use CTBS or LTBS in other District (Luwu District South Sulawesi) occurred in May 2008 and will be expanded to another district.
- Project start-up workshop (June 2006) to plan project activities in South Sulawesi and West Java (Makassar, 25 participants). These included Directors of Provincial and national agencies.
- Visits to field sites to meet local government, farmers groups and farmers by IRRI and CSIRO project staff, for project site establishment (February 2006) and associated follow-up visits and meetings (July 2006 and December 2006).
- ICRR have played a key role in the communication and dissemination activities for rodent management across Indonesia. This has involved posters, leaflets, models of CTBS, multiple live traps, fumigators, pictures of rodent controlling techniques etc. Furthermore, thousands visit the ICRR lab from across the country every year.

- ICRR has designed several activities (eg. research activities, open house, displaying techniques of rice cultivation and pest-diseases control etc.) to disseminate agricultural technologies to farmers, extension workers, students, decision makers, etc. ICRR received 35,920 visitors during 2008.

8.4.2 Interactions with extension staff

Vietnam

- Training on rodent biology, ecology, taxonomy and rodent control methods were given in 2006/07 to extension staff, as part of a "training-of-trainers" (TOT) approach to the dissemination of EBRM strategies. The training involved staff from CSIRO, NIPP and IAS.
- KAP&SE survey development and training workshop for project staff in An Giang province (Long Xuyen, 8-9 June 2006, 12 participants) and for project staff in Ha Nam province (Ha Nam, 12-13 June 2006, 15 participants).
- Training workshop for technical staff: In An Giang, 2 trainings were organised on rodent biology/ ecology and rodent management (one run by Mr La Pham Lan, IAS) at the end of Winter-Spring crop with the participation of 50 technical staff throughout the province, and one by Mr Nguyen Quy Hung (a former IAS scientist) and World Vision in Autumn-Winter crop with the participation of 25 technical staff. In Ha Nam, 20 technical staff were trained by PPD.

Indonesia

- Training on rodent biology, ecology, taxonomy and rodent control methods were given in 2007 to extension staff, as part of a "training-of-trainers" (TOT) approach to the dissemination of EBRM strategies. The training involved staff from CSIRO, ICRR and AIAT, South Sulawesi.
- KAP&SE survey development and training workshop for project staff in South Sulawesi (Makassar, 1-4 December 2006, 9 participants) and for project staff in West Java (Sukamandi, 6-7 December 2006, 8 participants).

8.4.3 Engagement with farmers

Vietnam

- Farmer workshops on ecological rodent management technologies organised in An Giang province (4 workshops with in total about 400 participating farmers) and Ha Nam province (4 workshops with in total about 200 participating farmers).
- End-season review workshops were held on project sites with farmers run by extension staff: Two review workshops were held in An Giang at the end of Summer-Autumn crop (June 2007, 50 participants including farmers) and Winter- Spring 2007-2008 (January 2008, 30 participants). In Ha Nam, a workshop was also conducted at the end of Mua season (October 2007, 50 participants).
- Training workshop for farmers: In An Giang, 4 trainings for farmers focusing on Community Action (CA) and CTBS implementation were held during the Summer-Autumn crop and 2 trainings in Autumn-Winter crop with the total of 300 farmers participated. In Ha Nam, 24 trainings on rodent management were organised with the total of 480 farmers participated across 4 crop growth periods.
- In Ha Nam, there were 4 CA activities conducted (CA: field hygiene, trapping, hunting with dogs, and fumigation) and dissemination activities were conducted in 4 additional areas outside the project site, with a total of 800 farmers involved.

- There have been 500 booklets printed (re-printing of the World Vision/ACIAR booklet on rodent management in rice based farming systems "*Quản lý chuột hại lúa*") for distribution among project staff, key farmers and available for the general farming community.
- 1000 leaflets on rodent management were printed and distributed to farmers in target provinces and neighbouring provinces.
- There were 64 meetings held with farmer groups during the summer crop 2008 in Ha Nam, run by project staff.
- A wide range of communication events and activities have been conducted. Some of these were tied in with the "3-reductions, 3-gains" program. There were also leaflets, posters, t-shirts and caps distributed to promote EBRM.
- Local TV show featured EBRM in Ha Nam. One of the extension staff provided weekly updates on rodent management strategies to the local TV channel as part of a show for farmers. This meant that the project was broadcast to a large number of farmers within the province and she was known as the "rat lady".

Indonesia

- Farmer groups (20-30 farmers each group) from Takalar, Soppeng, Enrekang District (South Sulawesi Province) and Polman District (West Sulawesi Province) visited Leppangan Village in 2007.
- Additional villages in West Java are implementing rodent management strategies after training workshops and through assistance of trained extension staff (Karang Jaya, Karang Sinom, Kamurang and Tamansari).
- Training workshop for farmers in Salo and Leppangan, Pinrang District.
- There was an interview with Dr Sudarmaji from ICRR which covered ecologically based rodent management through the local radio program (Legeg Sunda Gaya Menak, 106 FM).
- There was a special on air radio program in March 2007 that featured the activities of the rodent project at Karawang and involved another interview with Dr Sudarmaji.
- There was a national TV show (TPI & Metro TV) on an interactive dialogue on rodent management.
- In South Sulawesi, the staff converted the control site to treatment site. As part of the communication and dissemination activities, staff distributed leaflets and materials, set up and ran field days and demonstration sites in order to successfully connect with farmers to implement EBRM.

8.4.4 International Conferences

3rd ICRBM

The 3rd International Conference on Rodent Biology and Management (ICRBM) was held in Vietnam (Hanoi, August 2006), provided a great opportunity for project staff from Vietnam and Indonesia to exchange ideas and experiences and to present these to the wider scientific community. Dr Grant Singleton (IRRI) and Dr Peter Brown (CSIRO) were part of the conference organising committee. Conference papers and posters presented by project staff at the conference include:

Baco, D. and Ramlan (2006). Trap barrier system – the need for assessment and development. Oral presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

Nugraha, U., Sudarmaji, Herawati, N.A., and Baco, D. (2006). Research and development of rodent management in Indonesia. Poster presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

Palis F.G., and Singleton, G.R. (2006). The social and cultural dimensions of rodent pest management. Oral presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

Singleton, G.R., Sudarmaji, Jacob, J., Rahmini, Brown, P.R. and Krebs, C.J. (2006). Ecologically-based management to reduce rodent damage to lowland rice crops in Indonesia. Oral presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

Tuan, L.A. (2006). Experience in applying community trap barrier system in Binh Thuan Province, Vietnam. Poster presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

Tuan, N.P., Brown, P.R., Tuat, N.V. and Singleton, G.R. (2006). Ecologically based management of rodents in Vietnam. Plenary presentation at the 3rd International Conference on Rodent Biology and Management, Thang Loi Hotel, Hanoi, Vietnam, 28 August to 1 September 2006.

The proceedings of the conference on were published in the international journal: *Integrative Zoology*. Dr Peter Brown was one of the Special Editors of these issues. There were 23 papers printed in three special issues in 2007 and 2008, plus 3 editorial comments, of which three papers published from ACIAR related projects:

Brown, P. R. and Khamphoukeo, K. (2007). Farmers' knowledge, attitudes, and practices with respect to rodent management in the upland and lowland farming systems of the Lao People's Democratic Republic. *Integrative Zoology* **2**, 165-173.

Palis, F. G., Singleton, G., Sumalde, Z., and Hossain, M. (2007). Social and cultural dimensions of rodent pest management. *Integrative Zoology* **2**, 174-183.

Singleton, G. R., Brown, P. R., Jacob, J., Aplin, K. P., and Sudarmaji (2007). Unwanted and unintended effects of culling: A case for ecologically-based rodent management. *Integrative Zoology* **2**, 247-259.

4th ICRBM

The 4th International Conference on Rodent Biology and Management (ICRBM) was held at the University of Free State, Bloemfontein, South Africa from April 2010. The ACIAR rodent project had a high profile within the conference, contributing 12 papers/posters. We were unable to have a stronger presence (particularly representatives of staff from Vietnam and Indonesia) at this conference because supplementary funding was not available as part of the extension granted after the Review in May 2009. There was a particularly strong contribution to the Symposium on "Sociology/cultural aspects and Economics", with Dr Flor Palis (IRRI) giving the invited plenary paper. Ms My Phung from Vietnam studying at the University of Queensland, Gatton, won the prize for the best oral presentation (John Allwright Fellowship student). Dr Grant Singleton (IRRI) and Dr Peter Brown (CSIRO) played an active role on the conference organising committee. The papers and posters presented from the project team include:

Brown, P.R., My Phung, N.T. (2010). Dynamics of rodent damage to irrigated rice in Vietnam. Poster presentation.

Darbas, T., Roebeling, P.C., Brown, P.R., Baco, D., Razak, N., Sudarmaji, Anggara, A.W., and Herawati, N. (2010). Agricultural governance: A comparison of uptake of ecologically-based rodent management by rice farming communities in two Indonesian regions. Poster presentation.

Fletcher, C.S., Brown, P.R., van Grieken, M., Sudarmaji, Baco, D., Huan, N.H., and My Phung, N.T. (2010). Integrating social, economic and ecological models of community rodent control in Southeast Asia. Oral presentation.

My Phung, N.T., Brown, P.R., and Leung, L. K-P. (2010). The relationship between reproductive potential of Rattus argentiventer and their diet in a rice cropping ecosystem in Vietnam. Oral presentation. **Winner of best Student Oral Presentation**.

My Phung, N.T., Brown, P.R., and Leung, L.K-P. (2010). Changes in abundance and habitat use of rice field rats Rattus argentiventer in the rice fields of Vietnam. Oral presentation.

Palis, F. (2010). Can humans outsmart rodents? Learning to work collectively and strategically. **Invited Plenary Paper (oral)**.

Singleton, G.R., Htwe, N.M., Brown, P.R., and Belmain, S.R. (2010). Rodent outbreaks in Asia 2007-2009 - Rats! What do we do next? Oral presentation.

Sudarmaji, Herawati, N. Anggara, A.W., Singleton, G.R., Hinds, L.A. (2010). Increasing intensity of rice cropping in Asia - What are the implications for rodent management? Oral presentation.

Tung, T.T., Paul, D.C., and Hinds, L.A. (2010). Effects of different seed extracts and Nicotine on the reproductive tracts of laboratory rats (*Rattus norvegicus*). Oral presentation.

Tung, T.T., Blome, A. K., and Hinds, L.A. (2010). Laboratory evaluation of alternative baits to improve bait acceptance by ricefield rats (*Rattus argentiventer*). Oral presentation.

van Grieken, M., Roebeling, P.C., Zull, A., and Brown, P.R. (2010). Economic impacts of integrated rodent management strategies. Oral presentation.

van Wensveen, M., Brown, P.R., Sudarmaji, Razak, N., Baco, D., and Anggara, A.W. (2010). Knowledge, attitudes and practices for rodent management in South Sulawesi and West Java, Indonesia. Poster presentation.

Work is underway to get some of these papers published as part of special issues of journals.

IRRI conference on Rodent Outbreaks

This was the first conference on rodents held at IRRI for almost 20 years. There were about 30 participants, particularly drawn from developing countries of Southern and Southeast Asia (Bangladesh, Indonesia, Laos, Myanmar, Philippines, Vietnam) and resource people from USA, Philippines, UK and Australia (Dr Peter Brown and Dr Ken Aplin of CSE, Dr Lyn Hinds of CSIRO Entomology). The conference was co-organised by Dr Grant Singleton and Dr Steve Belmain.

This conference was prompted by a series of outbreaks of rodents that was initiated by flowering and subsequent masting (seeding) of a particular species of bamboo (*Melocanna* spp.) that occurs through Asia. This event occurs every 48-50 years. Fifty years ago in the Mizo Hills of India, severe regional famine led to civil unrest and a 20-year civil war against central Indian authority and the creation of Mizoram State in 1986.

Since 2005 there have been reports in Mizoram (India), Chin State (Myanmar), the Chittagong Hill Tracts (Bangladesh) and Lao PDR (4 upland provinces) of severe food shortages due to rodent outbreaks caused by bamboo masting events. Similar events have been reported in Argentina and Chile in recent years. Just as importantly, rodent population outbreaks occur in other agricultural systems where bamboo is not present.

The conference examined case studies of rodent outbreaks with a view to drawing generalities. There has been little documentation of the factors leading to rodent population outbreaks, their impacts, and the successes and failures of management actions, particularly in developing countries.

There was one paper in *SCIENCE* which reported on the conference (Normile 2010), one paper recently accepted for publication (Singleton et al. In Press), and a series of papers are being submitted for a special book being published by IRRI. Dr Grant Singleton and Dr Peter Brown are editors of this book (Singleton et al. in prep).

Normile, D. (2010). Holding back a torrent of rats. *Science* **327**, 806-807.

Singleton G. R., Belmain, S. R., Brown, P. R., Aplin, K. P., and Htwe, N. M. (In Press). Impacts of rodent outbreaks on food security in Asia. *Wildlife Research*.

Singleton G. R., Belmain, S. R., Brown, P. R., and Hardy, B. (In Preparation). 'Rodent Outbreaks - Ecology and Impacts.' (International Rice Research Institute: Los Baños, Philippines.)

Other meetings

- Oral presentation of Ecological Rodent Management at the 2007 Annual Meetings of the Entomological Society, Phytophatological Society, and Plant and Animal Protection Society (in South Sulawesi).
- There were various presentations of project information at annual meetings of the Entomological, Plant Protection and Pathological Societies of South Sulawesi. The presentations covered information about some of the results from this study to a wider IPM audience and scientists and extension staff working in the lowland irrigated rice agro-ecosystems.

9 Conclusions and recommendations

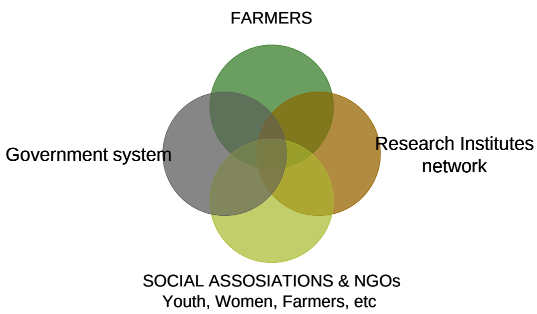
9.1 Conclusions

The success of this project is attributable to a number of factors. Chief among these have been the excellent collaboration between and across the various research and extension groups from Vietnam, Indonesia, Philippines and Australia. All project staff have been united in a single desire and approach to implement and increase the adoption of successful rodent management strategies that have been developed in Vietnam and Indonesia through previous ACIAR-funded rodent projects. Continued support from ACIAR and consistency in project staffing prior to this project has led to the maintenance of a core group that enabled the initial development and implementation of this project. Although there was a significant shift from "research" to "extension" and "adoption", the key researchers from previous projects maintained a strong involvement in the project as the extension component was established. To that end, the in-country lead agencies for this project were extension agencies, and it is testament to them that a seamless transition from the research to extension process occurred very successfully.

From 2006-2010, the development of effective partnerships with regional networks has greatly facilitated both scaling out to a wider number of farmers and scaling up to promote the inclusion of EBRM in agricultural policies and programs. The partnerships have allowed transfer of practices and knowledge to farmers and ensured that actions wee community driven. For example, ICRR AIAT and PPD have played a major role that is beyond their mandate for research. Because of this, the linkages facilitated through the leadership of ICRR in the multi-stakeholder platform have developed an impressive model for sustainable diffusion of EBRM.

Another significant component of this project was the multi-disciplinary team that was assembled in each of the main collaborating institutions (Figure 9.1). This led to a very lively and interesting project, but also allowed strong links to be developed between research and development arms of in-country institutions, also in the policy development arena. The future success of management rodents will be because of the policy interventions and incorporation of national training modules (eg "3-reductions, 3-gains" in Vietnam; Primitani, ICM in FFS, P2BN, and IP Padi 400 in Indonesia).

Figure 9.1. Relationship between various stakeholders in the development and implementation rodent management in Vietnam.



Within the core project team, there has been a strong "science to impact" and "science to publication" ethic. This will lead to the development of policy recommendations within Indonesia and Vietnam, and also ensure that the science will appear as world-class, peer-reviewed literature. A number of publications have already come out of this project and there are well developed manuscripts and plans for future publications (see section 10.2).

This project has also directly benefitted from one MSc and two PhD projects (John Allwright Fellowships).

A lesson learned from the project is the importance of local “champions”. These are the people on the site who have the capacity and interest to test new knowledge and technologies. These people have encouraged other farmers to adopt new technologies or have found ways to organise Community Actions and facilitate other important linkages. These champions acquired knowledge and information resources that shaped their understanding and actions on rodent control. Once farmers saw that EBRM was effective in the fields of the “champion” farmers, the diffusion of knowledge and practice is facilitated.

From a technical perspective, a limitation for implementing project practices and providing training is the lack of people who have the expertise on rodents. For example, there are currently only four rodent experts in Indonesia. These experts need to find effective ways to transfer their skills and knowledge to others who can then teach more people in the different provinces throughout the country. This requires investment in research capacity and extension because while site visits are essential, it consumes much time of the experts, particularly when research is their main mandate. One initiative ICRR staff identified that may help release the pressure on their time in the future, was to link with universities, by including EBRM in biological curricula. The aim in the medium term is to equip the next generation of agricultural scientists and extensionists with the requisite knowledge on the biology and management of rodents.

An identified need for effective scaling out is the availability of materials (such as CTBS materials) that demonstrate EBRM to those who are not experts on rodents or rodent management. These materials should complement communication materials, specifically, leaflets which are relatively easier and cheaper to produce, but match the materials with the need. The challenge is to involve communities in investing on those materials and making arrangements on maintenance of the materials.

The key outcomes from this project have been:

- Demonstration that EBRM can successfully reduce rodent damage to rice crops and increase yields;
- There are significant social benefits of applying EBRM through increasing a community approach to rodent management;
- There are significant environmental benefits of applying EBRM through the reduction in use of chemical rodenticides;
- Community Action (including synchronised cropping, field hygiene, community rodent campaigns early in the crop growth period and destroying rodent burrows early in the growth of the rice crop) can be successfully integrated within a normal farming management system to significantly reduce the impact of rodents. There is a very high likelihood that farmers will continue the Community Action approach to rodent management in the future.
- CTBS can be successfully employed to manage rodents when rodent densities are moderate to high, but it requires good planning and coordination among farmers. It is thought of as expensive, and farmers were often reluctant to invest in the technology early in the crop, or to prepare the early trap crop (the small field that is planted inside the plastic barrier to attract rodents). There is a low to moderate likelihood that farmers will continue to use the CTBS as a key rodent control strategy in the future without some kind of government support or subsidy.

transforming knowledge to communities on the population response of rodents often requires demonstrations of the impact of the crop management actions. For example, the rice-rice-rice cropping system in Citarik resulted in no yield for the third crop. There also were some problems in the neighbouring rice-rice villages such that during their

Community Actions, farmers were able to trap 400 rats in one week in a LTBS. The continuous interaction of experts and extensionists with the community allowed farmers to see that the rate of increase of the rodent population was directly related to their particular rice cropping systems.

However, despite the knowledge that farmers may already have acquired, there are still challenges that may hinder implementation of EBRM. One is that irrigation schedules may dictate asynchrony of cropping and the other is that share farming/absentee ownership of rice crops may result in the lack of motivation to participate in rodent control activities in the community.

In terms of communication and dissemination strategies, it is important to remember that the decision to adopt is rarely free of social and cultural context. Furthermore, understanding why existing practices are in place will help when introducing new ones. It is important to develop information delivery strategies that focus on individuals and institutions identified as important to the community in question. Reliance on traditional forms of media is unlikely to be successful.

9.2 Recommendations for management

This project has refined the management strategies for rodent for the lowland irrigated farming system in Indonesia and Vietnam. It builds on the findings from the previous ACIAR-funded rodent projects (AS1/1998/036; Brown et al. 2006; Singleton et al. 2005; Jacob et al. In Press). There are some general principles and practices that are regionally, or country-specific because of slight differences in the agro-ecosystems and species of rodents in those areas.

General

- Focus effort on early application of Community Actions (synchronised cropping, field sanitation, community campaigns at key times) and
- CTBS is useful in some circumstances (see below for further country-specific details).

Indonesia

- Use LTBS in specific areas to intercept rodents moving from source habitats into feeding (eg rice crop) habitats; and
- Use CTBS around rice seed nurseries if there is likely to be rodent problem.

Vietnam

The CTBS is useful under the following conditions in Vietnam. Some of the limitations of the CTBS are that it is expensive and requires constant maintenance, and that it can be problematic to set it up three weeks prior to planting the surrounding area because of constraints in availability of suitable land and irrigation water. The latter is more of a constraint in the Red River Delta than in the Mekong River Delta. The key conditions for its use are:

- In areas of the Mekong River Delta where flooding routinely occurs each year: CTBS is unlikely to be needed during first crop season; be prepared to use CTBS in second season.
- In areas of the Mekong River Delta where flooding does not normally occur: CTBS could be used during the first rice crop and the second rice crop. This is important for provinces near the mouth of the Mekong delta (e.g. Bac Lieu) because monsoon floods do not reset the rodent population;

- In Red River Delta: CTBS is unlikely to be needed during the first crop season because rodent numbers are generally low and serious damage does not normally occur in the first crop season; also it is difficult in establishing an early “trap crop” inside the plastic fence because of the cooler weather;
- In Red River Delta: consider using an aromatic variety of rice instead of early-planted “trap crop”; and
- The CTBS is useful in areas with large farm sizes.

9.3 Potential areas for future research

Further scaling out

The findings of this project support the desire to further scale-out the results into other provinces, especially within Vietnam (other provinces in the Red River Delta and the Mekong river Delta) and within Indonesia (other provinces severely affected by rodent damage). There needs to be a continued focus on the implementation of sustainable EBRM at national level within each country to finalise national policy developments, but also to further encourage the scaling out of sustainable EBRM technologies that have been demonstrated to be effective as part of this project. Scaling out should focus on other villages, districts, provinces, and to other countries. TOT is a key strategy.

Integrated project

The results and findings from this project could be integrated into a broader set of "best-bet" recommendations for pest (weeds, insects and rodents) and water resources in lowland irrigated highly intensive rice cropping systems in SE Asia. This approach would seek to provide a systems approach to develop a consistent delivery of comprehensive and integrated pest (weeds, insects and rodents) and water resources management to improve the livelihoods of small-scale lowland irrigated rice famers in Southeast Asia.

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10.2 List of publications produced by project

Publication type	Number of publications
Extension Materials	4
Conference Papers	33
Refereed Journal Papers	20
Advanced pipe-line papers	7
Thesis/Reports	3
Total	**67**

10.2.1 Extension materials relevant to farmers and extension staff

Departemen Pertanian (2007). Pengelaloan Tanaman Terpadu (PTT) Padi Lahan Rawa Lebak. Badan Penelitian dan Pengembangan Pertanian. 42 pp.

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2005

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11 Appendixes

11.1 Appendix 1: KAP&SE survey

logo

IAARD

Knowledge, Attitudes and Practices

&

Socio-Economic Survey

CSIRO

Australian Government

Australian Centre for International Agricultural Research

IRRI

INTERNATIONAL RICE RESEARCH INSTITUTE

Purpose of the survey: This program aims at aiding farmers in providing solutions for the sustainable management of rats. To this end, we need to obtain a proper understanding of farmers' attitude towards rats and their control in agricultural crops, particularly in irrigated rice production. We would like to ask you for some time to share with us your thoughts, experiences and current practices regarding rat management.

Respondent # ______________________ Interviewer ____________________

Name of farmer ______________________ Date of Interview ______________

Rukun tetanga ______________________ Rukun kampung ______________

Dusun ______________________ Farmer group name ______________

Village (desa) ________________ Sub-district ____________________

District ____________________ Province ____________________

I. Background Information

1. What is your Ethnic (Ethnolinguistic) Group? ______________________
   Do you speak Bahasa Indonesia? yes no
2. How many people are there in your household? ______________________
   (Household members are defined as family and non-family members living permanently in the household and taking food from the same kitchen)

1

3. How many children do you have? ____________________________

4. How many of your brothers/sisters live in the village? ____________________________

5. Name your non-household siblings and children (please tick) in the village and indicate their distance to the farm household (i.e. smallest distance between farm parcels):
   1. Name: ____________________ Distance to sibling's / child's farm: ____ km
   2. Name: ____________________ Distance to sibling's / child's farm: ____ km
   3. Name: ____________________ Distance to sibling's / child's farm: ____ km
   4. Name: ____________________ Distance to sibling's / child's farm: ____ km
   5. Name: ____________________ Distance to sibling's / child's farm: ____ km

6. How many years of farm management experience do you have? ________________________

7. Which non-government (non-paid) village organizations are you member of, what position do you occupy and how many members are there in the organization?

Organization	**Position occupied**	**Number of members in organization**

8. What local government positions do you occupy? Specify if elected or appointed.

Position	**Elected or appointed[1]**	**Paid**
		yes no
		yes no
		yes no
		yes no

Note: [1] 1 = elected, 2 = appointed.

II. *Socio-Economic and Demographic Characteristics*

Can you give us some information on the members in your household that live within as well as outside the village, and that are over 10 years old?

Household member Name	Relation to head of household[1]	Sex	[redacted]	Civil status[2]	Age (yrs)	Education (yrs)	Occupation			
							Type[3]	Time allocated (%)	Location	Average income[4] (Rph/mth)
Head of household			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
Spouse							1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
Children 1.							1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
2.							1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
3.							1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.

3

Household member name	Relation to head of household[1]	Sex	[redacted]	Civil status[2]	Age (yrs)	Education (yrs)	Occupation Type[3]	Time allocated (%)	Location	Average income[4] (Rph/mth)
4.			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
5.			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
Others: 1.			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
2.			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.
3.			[redacted]				1.	1.	1.	1.
							2.	2.	2.	2.
							3.	3.	3.	3.

Notes:
[1] Relation to head of household: 1=Wife/husband, 2=Son/Daughter, 3=Son/Daughter-in Law, 4=Brother/Sister, 5=Other (specify): ____________
[2] Civil Status: 1=Single, 2=Married, 3=Widow/Widower, 4=Separated, 5=Other (specify): ____________
[3] Occupation types: 1=Farmer, 2=Wage laborer, 3=Government official, 4=Other (specify): ____________
[4] If wage laborer, ask wage per day and number of days per month to estimate average income per month.

4

III. *Farm Household Characteristics and Cropping Pattern Nov 2005 – Oct 2006*

In this Section we will ask you some questions about the characteristics of the farm household as well as the cropping pattern in the year Nov 2005 – Oct 2006.

1. Resource availability: Can you give us some information on the capital resources (like land, livestock, machinery and structures) you have got available in your household at this moment?

Item		**Availability**		**Age**	**Value[1] when**
		Number	**Unit**	**(yrs)**	**bought (Rph/unit)**
Farm land:	- owned – bought				
	- owned – inherited				
	- share-cropping				
	- leased				
	- other: _________				
Livestock:	- cows				
	- ox / buffalo (carabao)				
	- goats				
	- chicken				
	- ducks				
	- fish				
	- other: _________				
Machinery/tools:	- hand-tractor				
	- rice dryer				
	- plough mills				
	- drum seeder				
	- water pump				
	- motor bike				
	- taxi-bike				
	- boat				
	- machete				
	- barrow				
	- thresher				
	- other: _________				
	- other: _________				
Fixed assets:	- goat pen				
	- poultry shelter				
	- rice drying area				
	- shed				
	- storage				
	- fish pond				
	- perennial crop				
	- store / shop				
	- other: _________				
	- other: _________				

Note: [1] For land, machinery and fixed resources, please ask for the value at the time of purchase. For livestock resources, please ask for the current value.

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2. Farm cropping pattern: Can you give us some information on the cropping pattern for the year Nov 2005 – Oct 2006 (2005 wet season crop, 2006 dry season crop and 2006 other crop)?

Parcel no.	Area	Elevation[1]	Tenure status[2]	Crop		Date of planting (dd/mm)	Date of harvest (dd/mm)	Total production		Price / kg (Rph) (F or D[4])	Would you plant it again? (Y/N)	Why (not)?
				Name[3]	Variety			Quantity (fresh)	Unit			
Wet season crop (2005): 11-2005 to 02-2006												
P1												
P2												
P3												
P4												
P5												
Dry season crop (2006): 04-2006 to 07-2006												
P1												
P2												
P3												
P4												
P5												
Other crop (2006) : 09-2006 to 10-2006 (Other crop)												
P1												
P2												
P3												
P4												
P5												

Notes: [1] Elevation type: 1=High, 2=Medium, 3= Low
[2] Tenure status: 1=Owner-cultivator, 2= Share-tenant, 3=Leasehold (fixed rent), 4=Other (specify): ___________
[3] Crop name: 1=Rice, 2=Corn, 3=Snake bean, 4=Eggplant, 5=Other (specify): ___________
[4] Quality: F=Fresh, D=Dry

3. In case you planted Sintanur rice variety, in what year did you first start planting Sintanur rice variety (year)? ______

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4. Product disposal: Can you give information on what you did with your farm produce in 11/05-10/06? Did you sell, store and/or keep it? Did you use it to pay creditors or lease? Note that farm produce not only includes the crops identified in question III-2 (e.g. rice, beans), but also includes livestock (e.g cows, chicken) and other products (e.g. eggs, milk).

Item	Other products				Livestock				Crops / Rice varieties								
	1	2	3	4	1	2	3	4	Wet season crops[2]			Dry season crops[2]			Other crops[2]		
									1	2	3	1	2	3	1	2	3
Product type																	
Total production: - Quantity																	
- Unit																	
Farmer's share:																	
1- Sold:																	
Quantity (units)																	
Price (Rph/unit)																	
Product Outlet: - type[1]																	
- distance (km)																	
2- Stored to sell later:																	
Quantity (units)																	
3- Kept for home consumption:																	
Quantity (units)																	
4- Kept for seeds:																	
Quantity (units)																	
Paid to creditor in kind:																	
1- Payment for inputs																	
Quantity (units)																	
2- Payment for services																	
Quantity (units)																	
Amortization/Leasehold fee:																	
Quantity (units)																	
Sharecrop fee:																	
Quantity (units)																	
Other (specify): ______________																	
Quantity (units)																	

Notes: [1] Type of outlet: 1=Government, 2=Retailer/trader, 3=Millers, 4=Cooperative, 5=Other (specify): __________

[2] Please refer to question III-2 for definition of different cropping seasons.

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5. Labor and input use in the dry season 2006 crop: Can you give us some information on the labor requirements and levels of input use in the dry season 2006 crop? **Please refer to the largest parcel only!**

i) How much family and hired labor did you use on the largest parcel in the dry season 2006 crop? Also, where did you get it from and how much did it cost?

Activity	**Family/exchange labor**				**Hired labor**					
	Number of days	**Number males working**	**Number females working**	**Hours per day**	**Number of days**	**Number males working**	**Number females working**	**Hours per day**	**Wage (Rph/day)**	**Contract wage (Rph/activity)**
Land preparation										
Cleaning/repair of dikes										
Seed(bed) / preparation										
Sowing / Transplanting										
Gap filling/replanting										
Hand weeding										
Herbicide application										
Molluscicide application										
Insecticide application										
Fungicide application										
Rodenticide application										
Fertilizer application										
Water pumping crop care										
Harvest/haul/thresh										
Transporting										
Drying										

ii) How much and what types of input did you use on the **largest parcel** in the dry season 2006 crop? Also, how much did the input cost and where did you obtain it?

Input	Application (number)[1]	DAT[2]	Brand name	Input use			
				Quantity	Unit (kg or l)[3]	Price (Rph/kg or l)	Source[4]
Seed							
Fertilizer	1.						
	_.						
	_.						
	_.						
	_.						
	_.						
Insecticide	1.						
	_.						
	_.						
	_.						
	_.						
	_.						
Herbicide	1						
	_.						
Molluscicide	1.						
	_.						
Fungicide	1.						
	_.						
	_.						
	_.						
Fuel/rent for threshing							

Notes: [1] Application number: 1=first application, 2=second application, etc. In case a farmer applies, for example, two types of fertilizers in one application, please repeat the application number in the following row.
[2] DAT=Days After Transplanting.
[3] If unit in quantity is given in bags, ask number of kilograms (kg) per bag. If quantity is given in bottle, ask number of liters (l) per bottle.
[4] Source: 1=Owned, 2=Purchased from shops, 3=Exchange with co-farmers, 4=cooperative, 5=Other(specify):___________

6. Access to sources of financial capital: Can you give us an *estimate* on how you financed your variable production costs (e.g. planting, fertilizer, pesticides and harvesting costs) in the 2006 dry season crop?
   Also, can you give us an *estimate* on how you usually finance capital investments, like for example the purchase of machinery/tools and fixed assets? Please refer to Question III-1 for examples of machinery/tools and fixed assets!
   Finally, can you give us an *estimate* on the rate of interest you pay for the use of these sources of finance? Please indicate interest rate *and* loan period!

Source of finance	**Variable input costs**			**Capital investment costs**		
	How did you finance variable input costs in the dry season 2006 crop? (% total variable input costs)	**Interest rate (%)**	**Period (months)**	**How do you usually finance capital investment costs? (% total investment costs)**	**Interest rate (%)**	**Period (months)**
Savings						
Family members						
Leaser						
Input supplier						
Wholesaler						
Credit cooperative						
Local bank						
Other: ________						
Total	100%			100%		

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IV. *Rodent and Other Crop pests*

In this Section we will ask you some questions about general factors (pests, diseases, too much rain, etc) that affect your crop production.

1. What are the main factors that limited crop production on your farm in 11/05-10/06?

Crop[1]	Main factor[2]	Estimated crop loss (%)		
		Wet season 2005-2006 crop	Dry season 2006 crop	Other 2006 crop

Notes: [1] Crop name: 1=Rice, 2=Corn, 3=Snake bean, 4=Eggplant, 5=Other (specify): ___________
[2] Main factor: 1=BPH, 2=Rats, 3=Stem borer, 4=Golden snail, 5=Other (specify): ___________

2. What is the most important rice pest to control?

____

3. How do you assess rat damage in your rice crop?
Note: Do not provide/show options to farmer!

i) Unearthed plants/seeds
ii) Visual observation
iii) Droppings
iv) Burrows
v) Tracks
vi) Run-ways
vii) Cut seedlings
viii) Damaged plants
ix) Others (specify) _______________
____

4. How do you describe the occurrence of rat damage in your rice crop? Choose one of the following:

   Regular Occasional Rare

   If not already stated in Question IV-1, what is the estimated yield loss? ______ %

5. Can you remember any specific years in the past when there were very high rat numbers? Which years? And why do you think it happened?

Year	Reason

6. Do you know if there is more than one species of rat present on your farm, and where do you predominantly find them?

Rat species[1]	Location[2]

Notes: [1] Rat specie: 1=Rice field rat, 2=House mouse, 3=Bandicoot, 4=____________
[2] Location: 1=Field, 2=Store, 3=____________

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V. *Knowledge on Rodent Pest Management*

In this Section we will ask some questions regarding your experience in rodent management. I will read some statements and please answer a) yes if you agree, b) no if you do not agree, and c) maybe if not sure.

1. Planting almost at the same time (within a span of two weeks) can reduce rat population.

   yes no maybe

2. The practice of fallow (no crops planted) almost at the same time can reduce rat population during the following crop.

   yes no maybe

3. Cleaning on farm and surroundings areas (general hygiene including village gardens) can reduce rat population.

   yes no maybe

4. Wide width of paddy bunds (>30 cm) can reduce rat population.

   yes no maybe

5. Small width of paddy bund (<=30 cm) can reduce rat population.

   yes no maybe

6. Individual rat control action is best to control rat damage because farmer has option when and where to conduct rat control.

   yes no maybe

7. Community rat control is best to control rat damage because it is done at the same time.

   yes no maybe

8. Community rat control for 2 continuous weeks at the early stage of the rice crop (before the tillering stage) is most effective in reducing rat population.

   yes no maybe

9. Community rat control at anytime of the cropping season is most effective in reducing rat population.

   yes no maybe

10. Community rat control at a specific stage of crop is most effective in reducing rat population.

    yes no maybe

VI. Farmers' Attitudes and Beliefs towards rats and rat management

In this Section we will ask you some questions regarding your opinion and beliefs about rats in general and rat management in particular.

1. Do you believe that:

Item	Yes	No	Don't know	Why?
1. Controlling rats is important?				
2. Rats can be controlled?				
3. Rat control must be done during rice growing season?				
4. Rats have to be controlled after harvest or in the fallow season?				
5. Chemicals used to control rats are safe (for humans, other animals and the environment)?				
6. By controlling rats, a farmer can increase his rice yields?				
7. Rats can cause severe yield losses?				
8. Rats can be only controlled if farmers work together with other farmers at the same time?				

2. Do you believe that rats carry diseases? yes no maybe

   If yes, what are those diseases: ______________________________
   ____
   ____

3. Do you know somebody who got sick due to rats? yes no maybe

   If yes, who: ______________________________

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VII. *Rat management practices*

In this Section we will ask you some questions about rat management practices in general and in rice production in particular.

1. Rat control in fields. What methods do you use to control rats in the field, when and how often do you apply them, what do they cost, and how effective are they?

Rat control method[1]	Appli-cation method[2]	Number of appli-cations[3]		Cost per application[3] (Rph)		Household labor use per application[4]				Rank effectiveness of control method[5]	Rank preferred control method[6]	Reason for preference ranking
						Number of persons in household needed		Number of days	Number of hours/day			
		DS	WS	DS	WS	Male	Female					

Notes:
[1] Rat control method: 1=Synchronized cropping, 2=Hunting, 3=Barrier system, 4=Trap barrier system, 5=Traps, 6=Digging, 7=Field hygiene, 8=Rat poison, 9=Smoke out, 10=____________
[2] Application method: 1=Individual, 2=Farmer group, 3= Community, 4=Contractor, 5=____________
[3] Applications: DS=Dry Season, WS=Wet Season; Please place dash (-) if not applicable.
[4] Household labor use: Please place dash (-) if not applicable.
[5] Effectiveness ranking: 1=High, 2=Medium, 3=Low
[6] Preference ranking: 1=highest preference, 2=second highest preference, 3=third highest preference, etc.

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2. At which stage of rice growth do you control rats?

Stage	Rats controlled[1] (Y/N)			How many times[1] (number)			When most effective[1,2] (score)			Why most effective?
	C1	C2	C3	C1	C2	C3	C1	C2	C3	
Seedling (days 0-20)										
Tillering (days 21-40)										
Booting (days 41-60)										
Heading (days 61-70)										
Maturing (days >70)										
Throughout season										

Notes: [1] Crop (see Question III-2): C1=Wet season crop, C2=Dry season crop, C3=Other crop
[2] Effectiveness score: 1=High, 2=Medium, 3=Low

3. At which stage/season of CROP (not rice) growth, is rat control most effective?

Crop name: _________ Stage: _________
Crop name: _________ Stage: _________
Crop name: _________ Stage: _________

4. If group/community control method, who organized the group/community effort to control rats?

Organizing party	Please tick box
Local government	
Farmer group	
Extension staff from AIAT	
Other (specify): -___________	
-___________	

5. What do you do with the rats caught?

Allocation caught rats:	%	Price (Rph/rat)
- Throw out / burn / burry		
- Sell		
- Other (specify): _____________		

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6. i) Do rats damage rice in your rice stores? yes no
   ii) If yes, how do you detect the presence of rats in your store?
   1.____
   2.____
   3.____
   iii) How do you protect your stores from rat damage?
   1.____
   2.____
   3.____

7. Your decision on rat control methods is based on:
   Note: Do not provide/show options to farmer!
   i) Your own experience
   ii) Your partner's experience
   iii) Trader or Seller
   iv) Extension Staff
   v) Training
   vi) New information (Radio, TV, Leaflet)
   vii) Other (specify): ___________________________

8. What is the average width of your paddy bund (cm)? _______________

9. Have you heard of the trap-barrier system? yes no
   If yes:
   i) Where did you hear about the trap-barrier system?
   1.____
   2.____
   ii) Do you think there would be any benefits from using the trap-barrier system as a rat control method? If so, what are these benefits?
   1.____
   2.____
   iii) Do you think there would be any problems with using the trap-barrier system as a rat control method? If so, what are these problems?
   1.____
   2.____

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VIII. Collective Action and Cooperation

In this Section we will ask some questions about your involvement in community activities over the last year.

1. In the past year, have you worked with others in your village/neighborhood to do something for the benefit of the community? yes no

2. If yes, what were the five main such activities last year? Was participation in these voluntary or compulsory? Were there cash contributions? If yes, how much?

Activity	Type of participation[1]	Cash contribution		Number of persons involved in activity *or* % of village members
		Rph	Period	
1.				
2.				
3.				
4.				
5.				

Note: [1] Type of participation: 1=Voluntary, 2=Compulsory

3. In the past year, how many times have you attended any of the following meetings?
   i) Village council meeting ____________________
   ii) Neighborhood meeting ____________________
   iii) Farmer cooperative meeting ____________________
   iv) Farmer club meeting ____________________
   v) Other (specify):____________ ____________________

IX. Sociability, Social Cohesion, and Inclusion

1. How would you rate the social unity of this village/neighborhood (circle)?

1	2	3	4	5
Very bad	Bad	Normal	Good	Very good

Comments: 1.____

2.____

2. In general, in your daily living, to who do you usually talk to or interact with? Where and what is the usual topic of discussion?

Who[1] (Person number)	**Relationship[2]**	**Where**	**Usual topic of discussion[3]**

Note: [1] Who: 1=person number one, 2=person number two, 3=person number three, etc.
[2] Relationship: Write down multiple relationships if applicable, e.g. neighbor and a friend;.
[3] Topic: For example crop production, purchase of inputs, marketing of produce, etc.

3. How many times in the past year (Nov 2005 till Oct 2006) did you participate in a family/village/neighborhood festival or ceremony (please **specify** - like wedding, funeral, religious festival, etc.)?

____

4. Do you often make decisions that affect your everyday life (circle)?

1	2	3	4	5
Never	Hardly ever	Sometimes	Almost always	Always

X. *Information and Communication*

Finally, we would like to ask you some questions regarding the sources of information that you use in your daily production decisions.

1. What are the five most important sources of information for agricultural technologies and markets?

   Please rank top 5, where 1 is highest, 2 is second highest, … and 5 is fifth highest.

Source of information	**Agricultural technologies (rank top 5)**	**Market e.g. product and input prices (rank top 5)**
Relatives		
Friends		
House neighbors		
Farm neighbors		
Television		
Radio		
Pamphlet		
Community or local newspaper		
National newspaper		
Community bulletin		
Community bill boards		
Farmer group / cooperative		
Groups or associations		
Community leaders		
PPD		
Ag extension staff		
NGOs		
Other (specify): _____________		

2. In general, compared to five years ago, has access to information improved, deteriorated or remained about the same?

   Improved   Remained the same   Deteriorated

   Why? 1.____

   2.____

3. What kind of farm-based training have you attended in the past year?

Name of course / training	Topics covered	Duration of training (days)

Thank you very much for your time!

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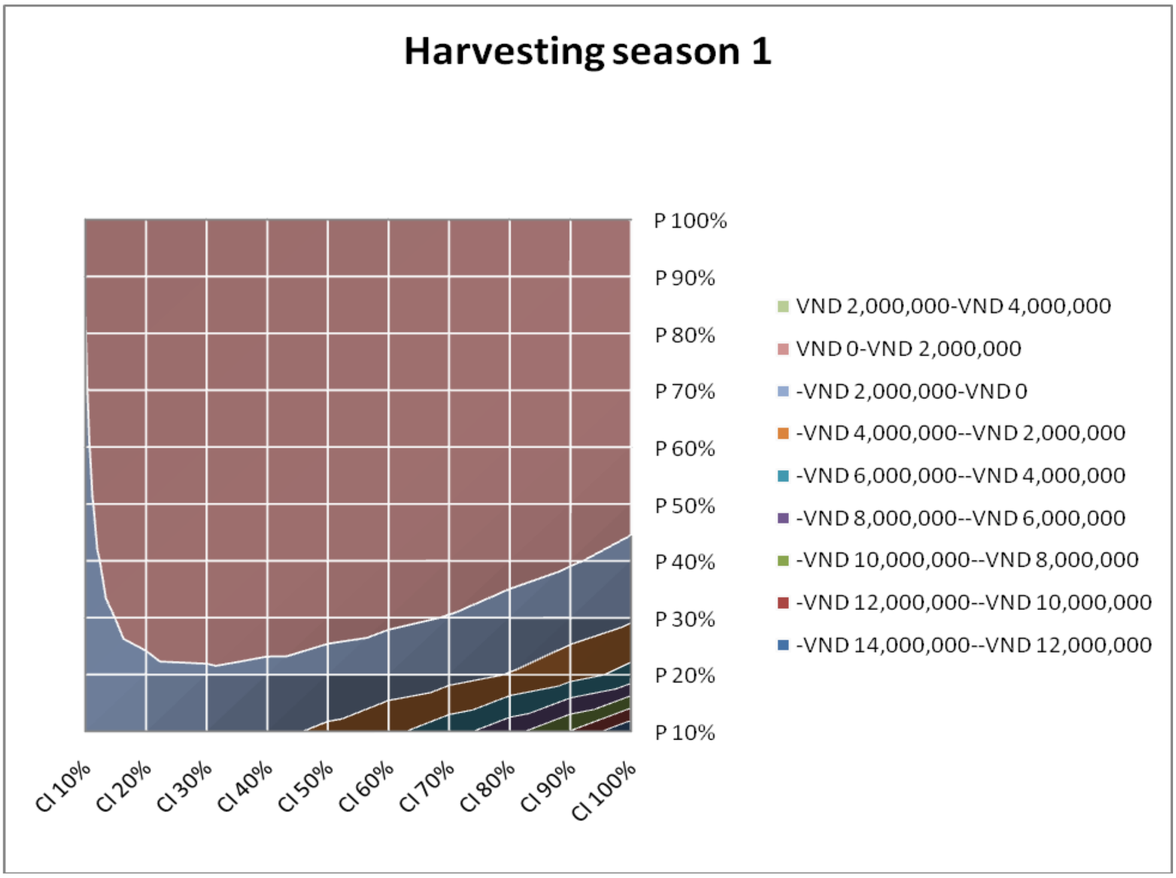
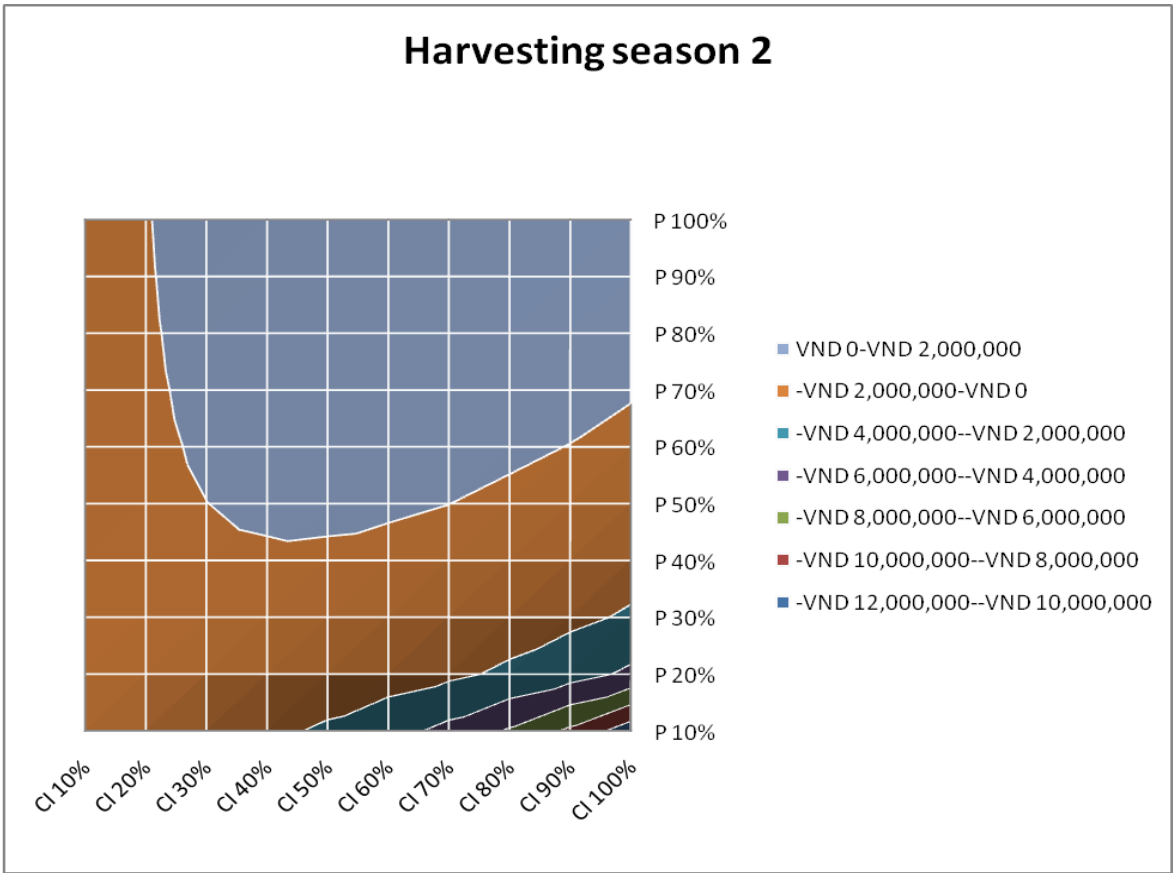
11.2 Appendix 2: Economic Modelling Results

This series of graphs below are the results from the economic modelling described in Section 5.3.7 and presented in Section 7.5.2. These graphs show the relationship of economic benefits with control intensity (x-axis: CI 10% to CI 100%) and the community participation (y-axis: P 10% to P 100%). The graphs are presented for both types of farms (Farm Type 1 are small farms: 2.5 ha; Farm Type 2 are large farms: 5.1 ha) and for each of the three harvesting seasons for Community Actions and for CTBS.

Community Actions FT1




Harvesting season 2
P 100%
P 90%
P 80%
P 70%
P 60%
P 50%
P 40%
P 30%
P 20%
P 10%
CI 10%
CI 20%
CI 30%
CI 40%
CI 50%
CI 60%
CI 70%
CI 80%
CI 90%
CI 100%
VND 0-VND 2,000,000
-VND 2,000,000-VND 0
-VND 4,000,000--VND 2,000,000
-VND 6,000,000--VND 4,000,000
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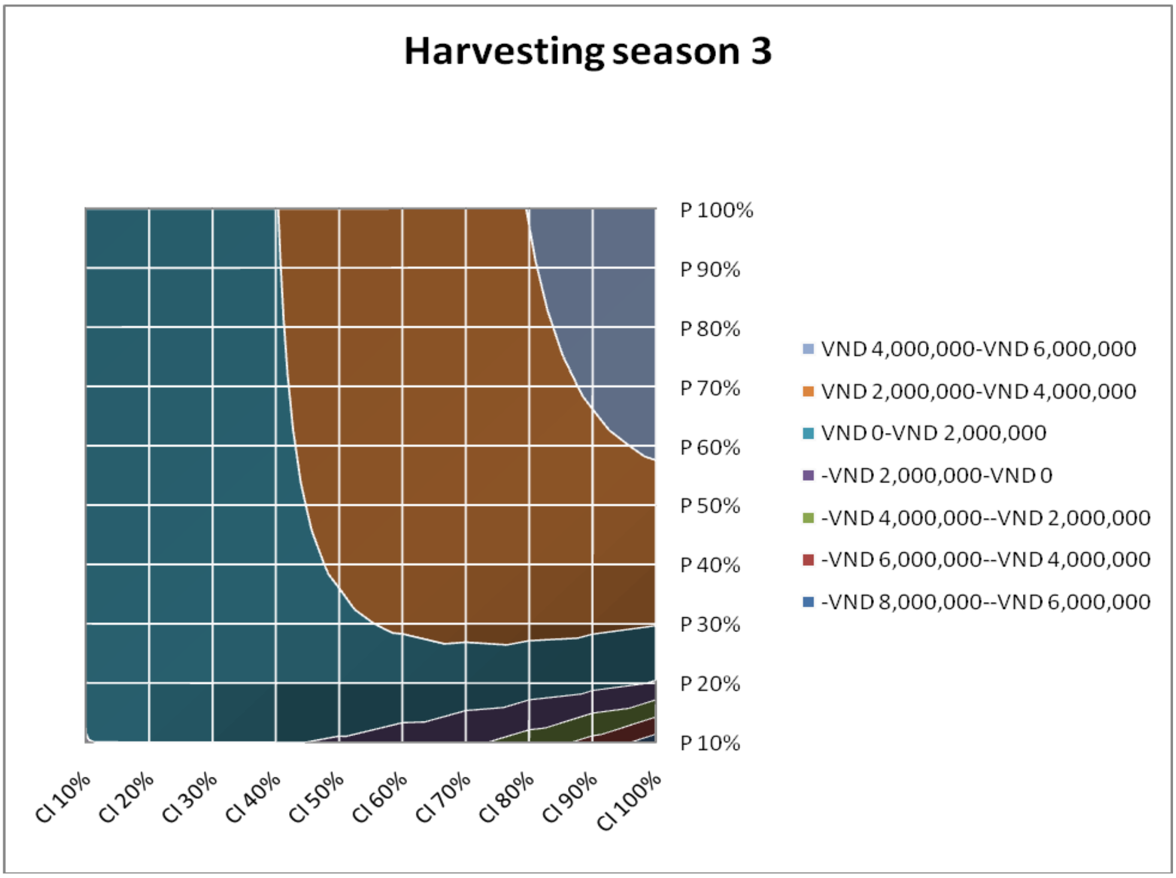
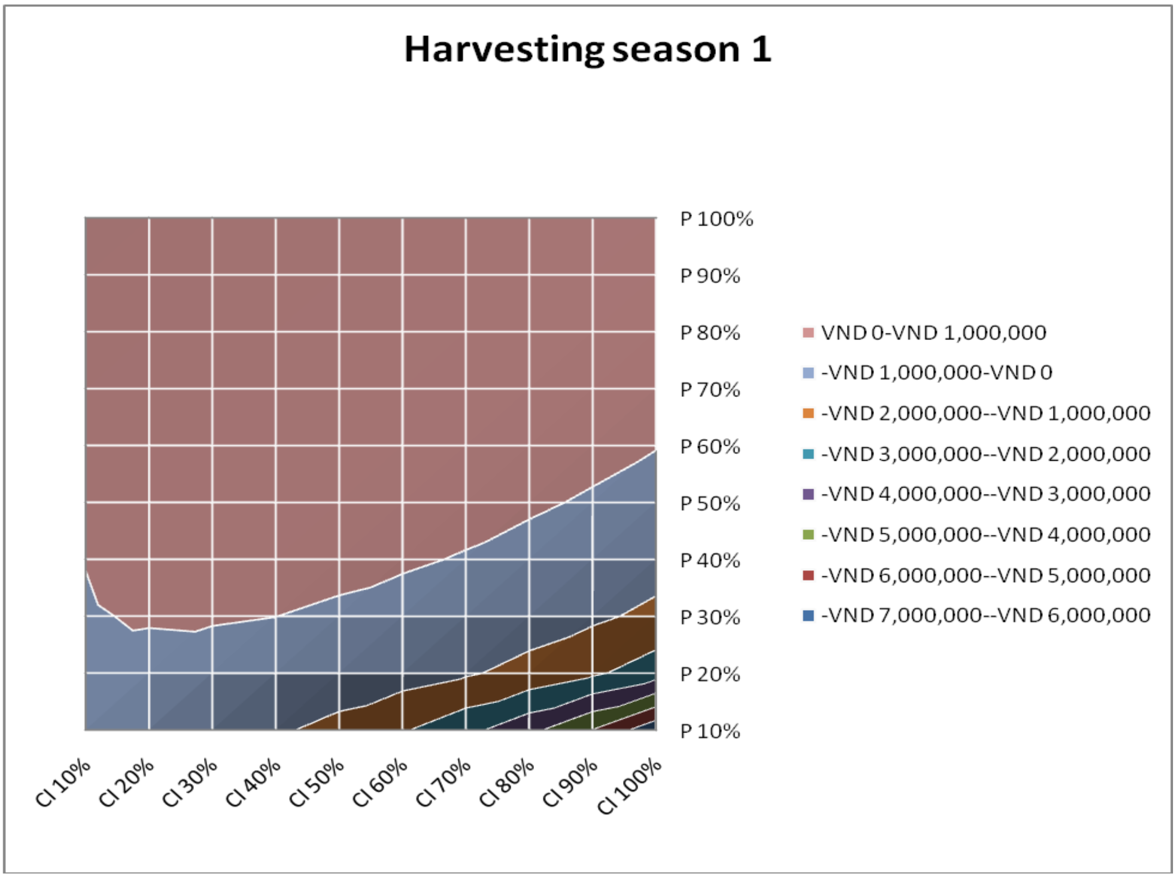
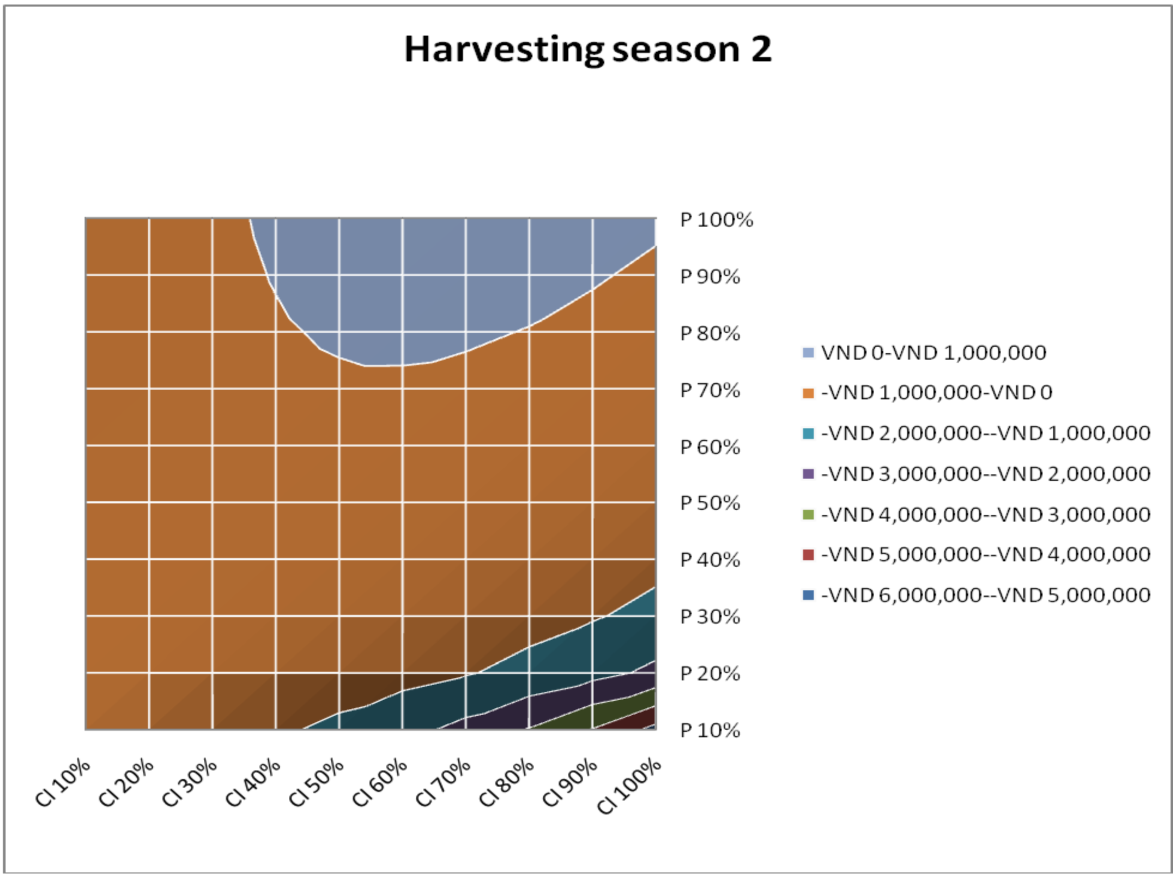
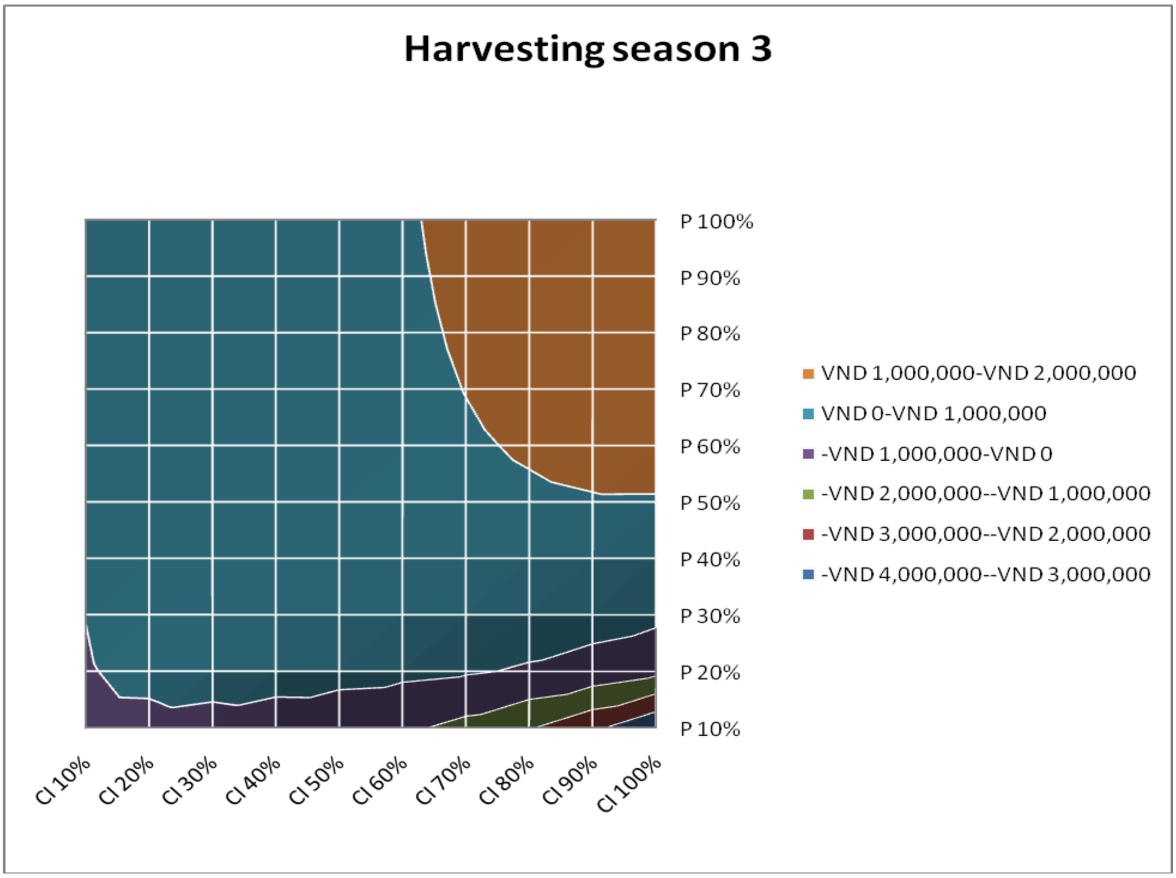
-VND 10,000,000--VND 8,000,000
-VND 12,000,000--VND 10,000,000


Harvesting season 3
P 100%
P 90%
P 80%
P 70%
P 60%
P 50%
P 40%
P 30%
P 20%
P 10%
CI 10%
CI 20%
CI 30%
CI 40%
CI 50%
CI 60%
CI 70%
CI 80%
CI 90%
CI 100%
VND 4,000,000-VND 6,000,000
VND 2,000,000-VND 4,000,000
VND 0-VND 2,000,000
-VND 2,000,000-VND 0
-VND 4,000,000--VND 2,000,000
-VND 6,000,000--VND 4,000,000
-VND 8,000,000--VND 6,000,000

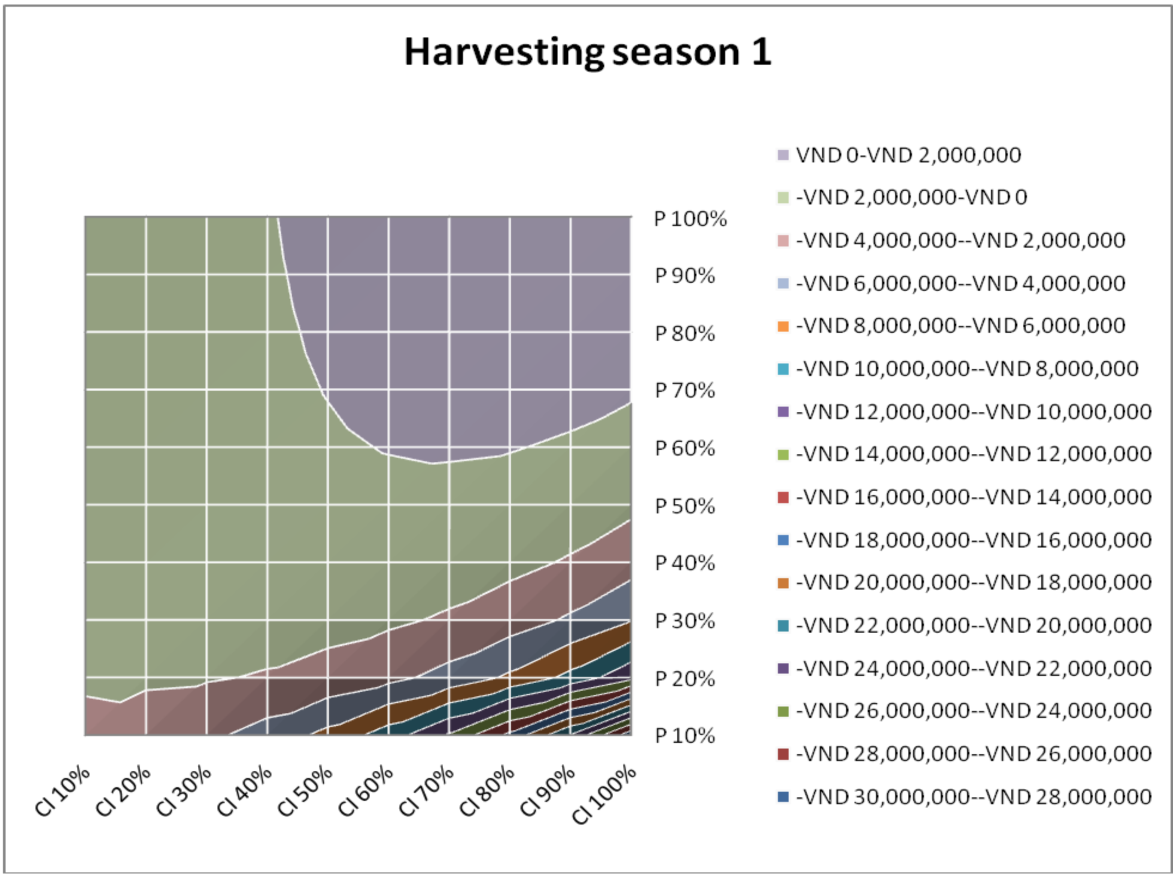
Community actions FT2

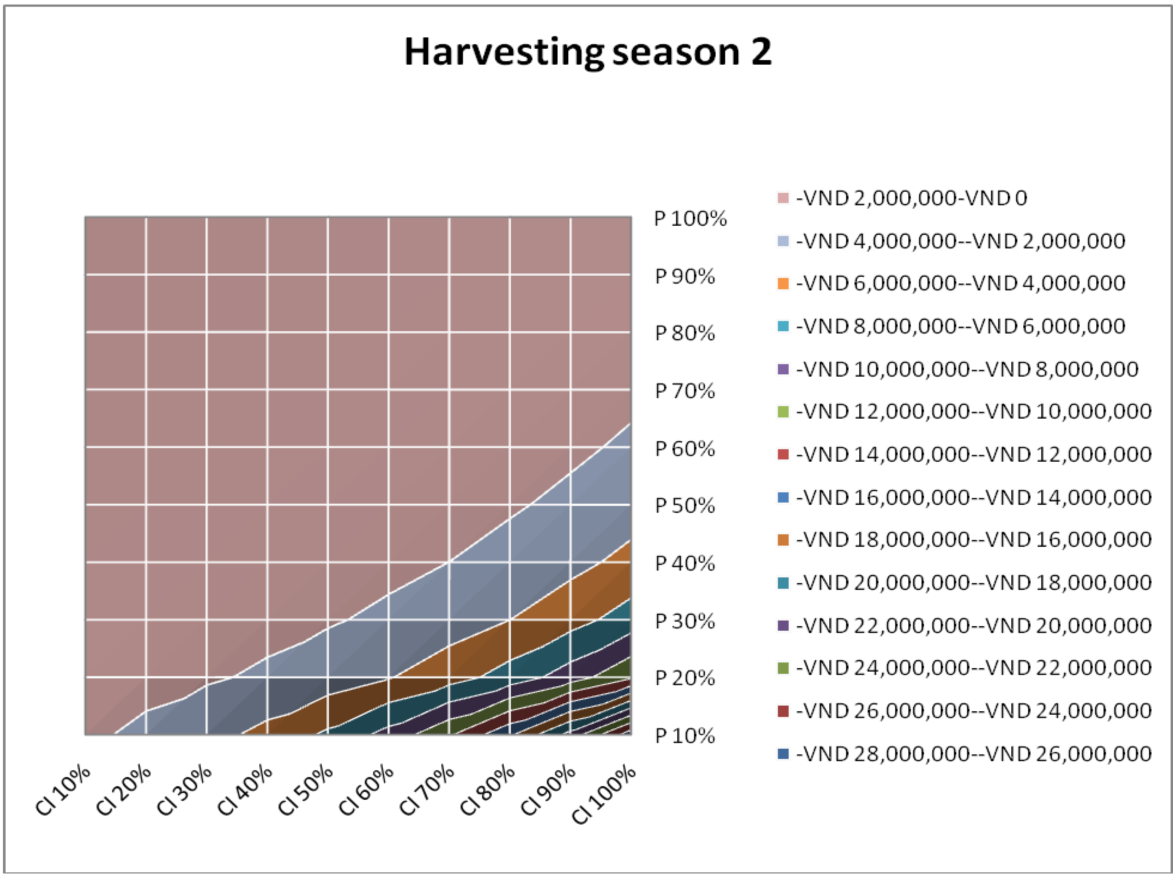






Community Trap Barrier System FT1




Harvesting season 2
P 100%
P 90%
P 80%
P 70%
P 60%
P 50%
P 40%
P 30%
P 20%
P 10%
CI 10%
CI 20%
CI 30%
CI 40%
CI 50%
CI 60%
CI 70%
CI 80%
CI 90%
CI 100%
-VND 2,000,000-VND 0
-VND 4,000,000--VND 2,000,000
-VND 6,000,000--VND 4,000,000
-VND 8,000,000--VND 6,000,000
-VND 10,000,000--VND 8,000,000
-VND 12,000,000--VND 10,000,000
-VND 14,000,000--VND 12,000,000
-VND 16,000,000--VND 14,000,000
-VND 18,000,000--VND 16,000,000
-VND 20,000,000--VND 18,000,000
-VND 22,000,000--VND 20,000,000
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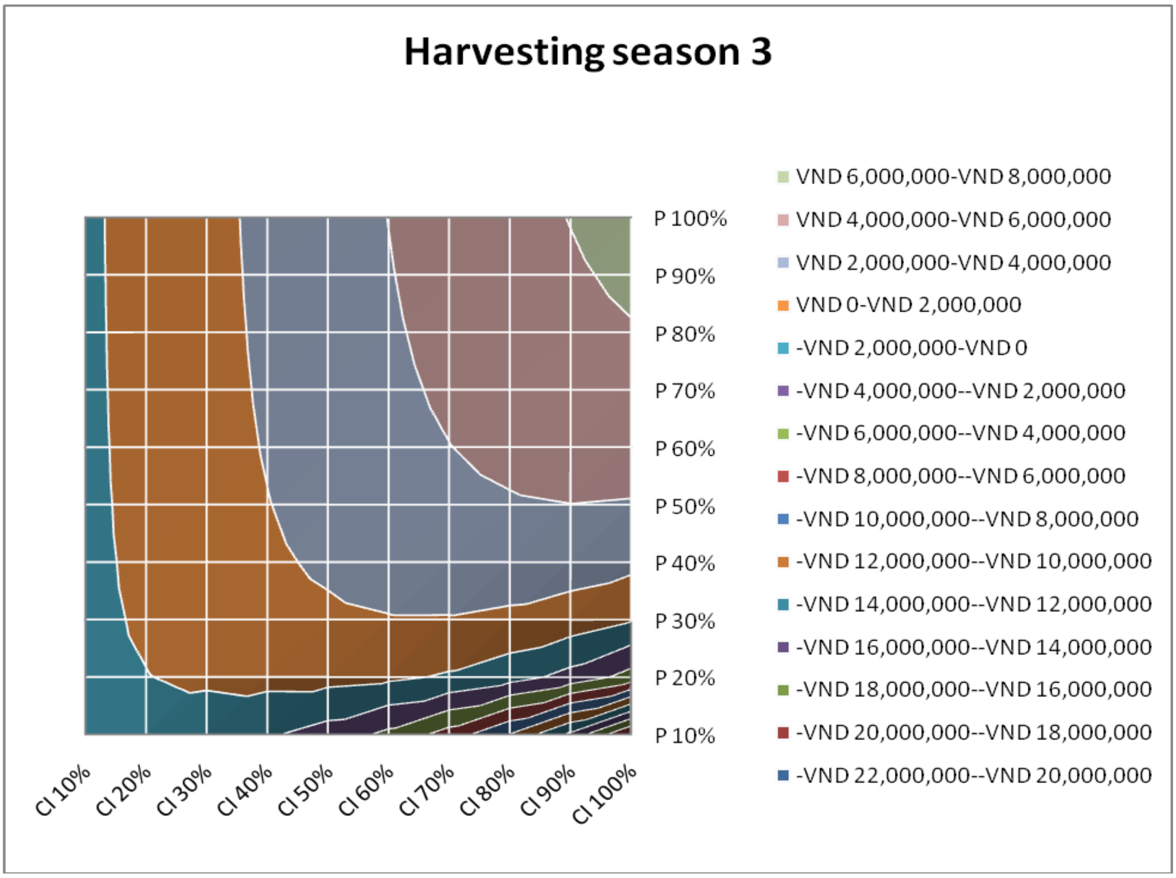
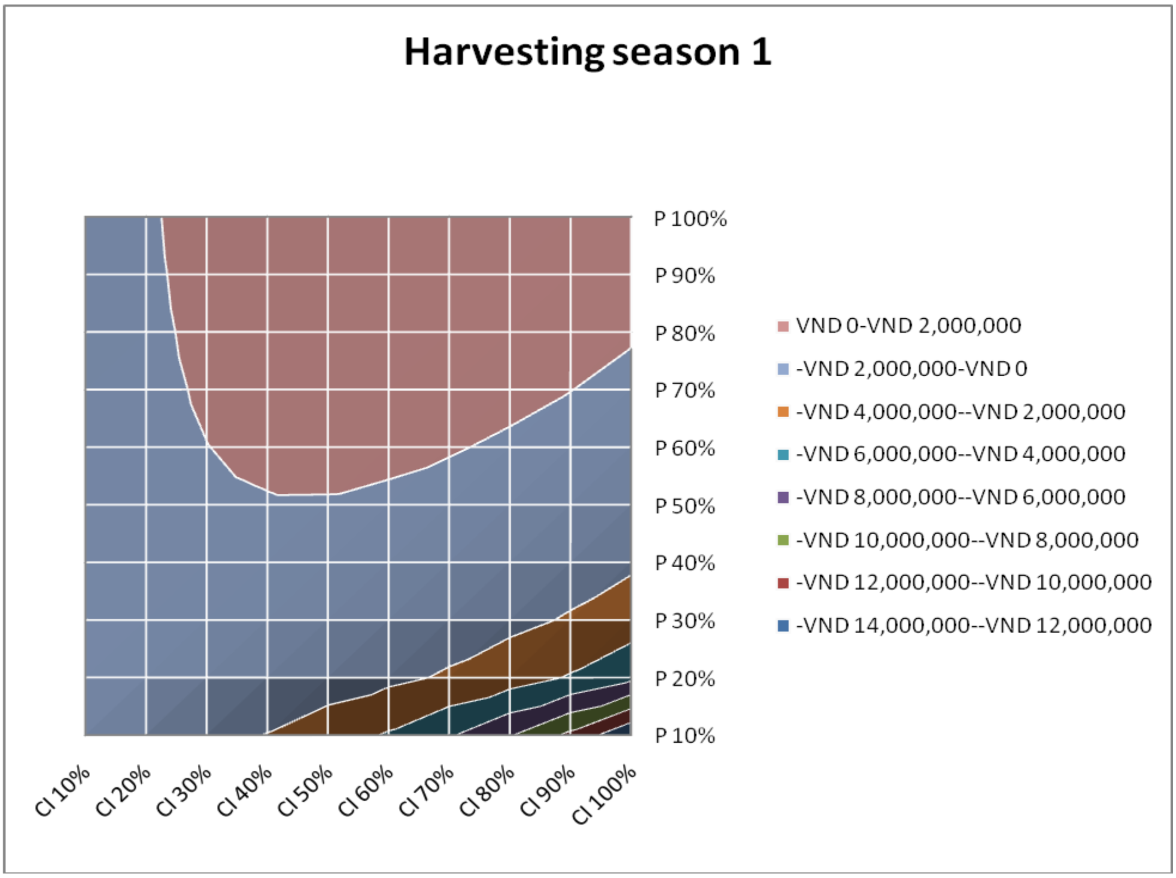
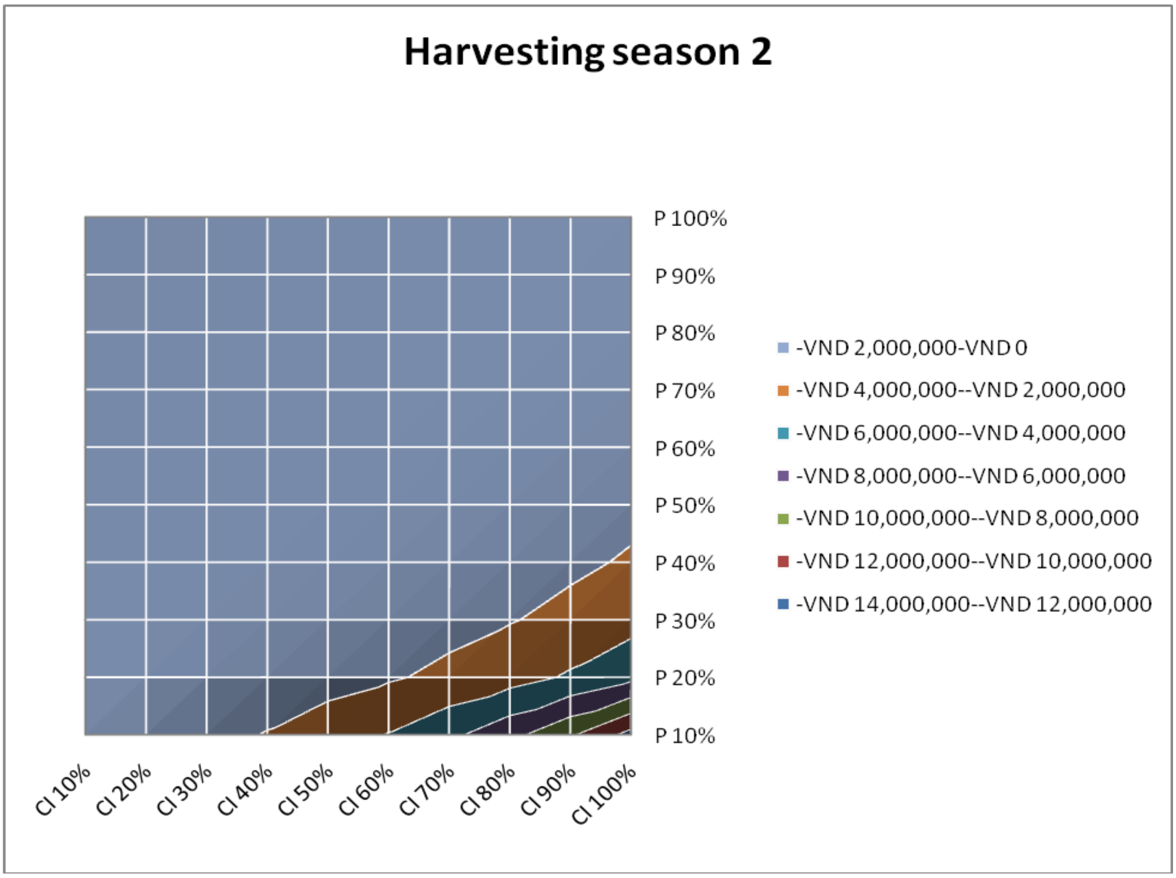
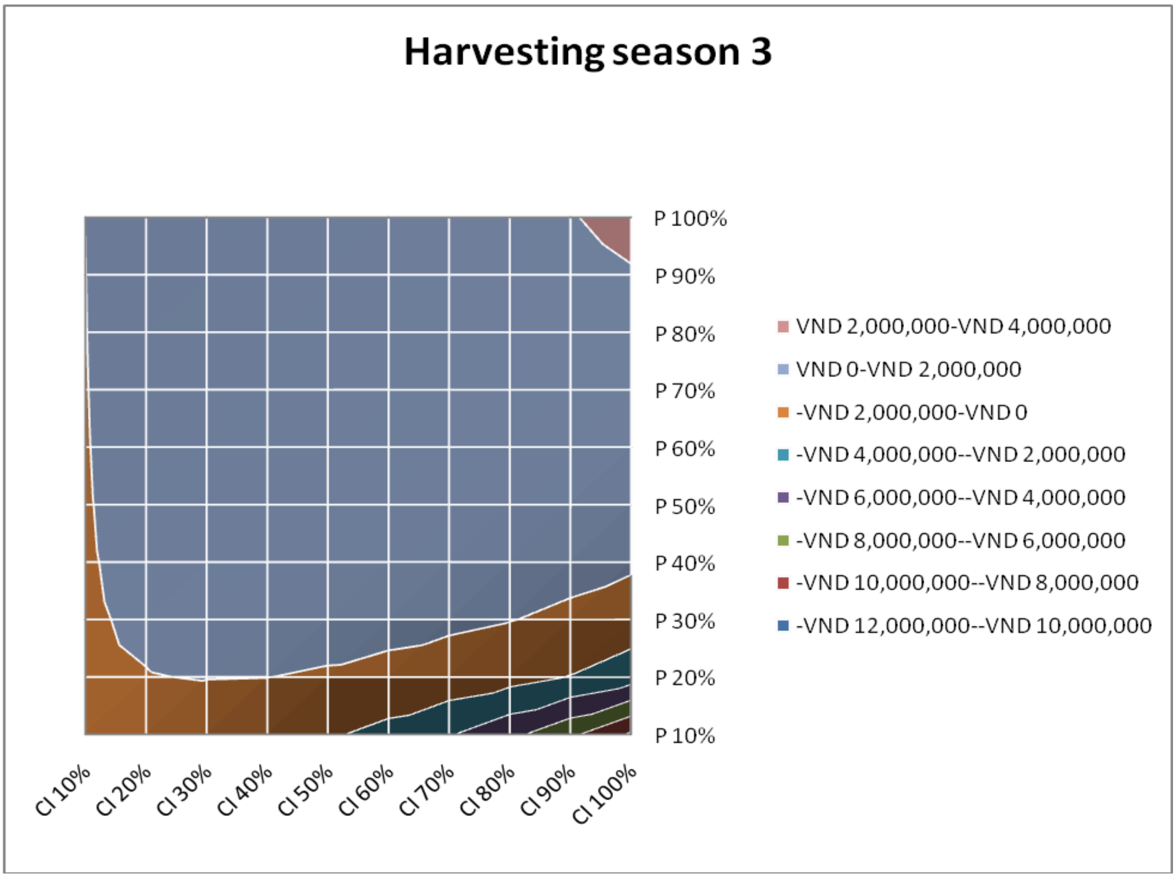
-VND 26,000,000--VND 24,000,000
-VND 28,000,000--VND 26,000,000


Harvesting season 3
P 100%
P 90%
P 80%
P 70%
P 60%
P 50%
P 40%
P 30%
P 20%
P 10%
CI 10%
CI 20%
CI 30%
CI 40%
CI 50%
CI 60%
CI 70%
CI 80%
CI 90%
CI 100%
VND 6,000,000-VND 8,000,000
VND 4,000,000-VND 6,000,000
VND 2,000,000-VND 4,000,000
VND 0-VND 2,000,000
-VND 2,000,000-VND 0
-VND 4,000,000--VND 2,000,000
-VND 6,000,000--VND 4,000,000
-VND 8,000,000--VND 6,000,000
-VND 10,000,000--VND 8,000,000
-VND 12,000,000--VND 10,000,000
-VND 14,000,000--VND 12,000,000
-VND 16,000,000--VND 14,000,000
-VND 18,000,000--VND 16,000,000
-VND 20,000,000--VND 18,000,000
-VND 22,000,000--VND 20,000,000

Community Trap Barrier System FT2






Harvesting season 3
P 100%
P 90%
P 80%
P 70%
P 60%
P 50%
P 40%
P 30%
P 20%
P 10%
CI 10%
CI 20%
CI 30%
CI 40%
CI 50%
CI 60%
CI 70%
CI 80%
CI 90%
CI 100%
VND 2,000,000-VND 4,000,000
VND 0-VND 2,000,000
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-VND 6,000,000--VND 4,000,000
-VND 8,000,000--VND 6,000,000
-VND 10,000,000--VND 8,000,000
-VND 12,000,000--VND 10,000,000