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Adoption and Impacts of Ecologically-Based Rodent Management in the Mekong Delta Region

ABSTRACT

Since 1995, the Australian Center for International Agricultural Research has funded eight ecologically-based rodent management (EBRM) projects to address rodent problems in three countries in Mekong Delta Region, namely: Vietnam, Lao PDR, and Cambodia. This paper aims to analyze the adoption and impacts of EBRM among rice farmers in Cambodia, Lao PDR, and Vietnam; the facilitating and constraining factors in its adoption, and lessons learned that could guide EBRM implementation in the future. The study utilized more of a qualitative approach anchored on an impact pathway framework. Data were gathered through focused group discussions among farmers from 19 villages, key informant interviews among key cooperators from collaborating agencies, and review of project documents and scientific papers published from the projects in the three countries. The ACIAR rodent control projects have brought about widespread adoption and significant impacts- economic, environmental, and socio-cultural- of EBRM in Vietnam but were limited in Lao PDR and Cambodia. The interplay of political, socio-cultural, historical, and economic factors is critical in the adoption of EBRM, and therefore, must be considered in promoting EBRM.

Key words: *Ecologically-based rodent management, rodent control, community trap barrier system, dissemination, adoption*

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INTRODUCTION

Rodents are considered one of the major constraints on rice farming in Asia during both the pre-harvest and postharvest stages of cultivation (*Singleton 2003*). Rodents are among the top three pest problems in rice production in Cambodia, Lao PDR, and Vietnam *(Jacob, Sudarmaji & Singleton 2003*; *Singleton 2003*; *Douangboupha et al. 2010; and Frost 2007*). *Singleton* (*2003*) estimated the pre-harvest losses in the uplands of Lao PDR at 10-15% and higher during outbreak years, 50-100%. In Cambodia, rodents remained an important pests but there is no national estimate of the losses attributed to rodents. Although, in a village where irrigated rice was the main production system, a majority of farmers estimated that losses caused by rats were greater than 20% (*Singleton 2003*). *Cuong et al.* (*2003*) estimated the pre-harvest losses for Vietnam at 5-10% but these losses vary considerably from season to season and year to year.

In Asia, losses to the pre-harvest yield of rice from rodent infestation are estimated to total between 5 and 10% (*Singleton 2003*). If no serious action is taken to control rodents, annual losses to rice harvests in Asia could be as high as 30 million tons, which is enough to feed 180 million people for 12 months (*Aplin et al. 2006*). Thus the impact of rodent damage in rice production, particularly in Cambodia, Lao PDR and Vietnam is important considering that rice is the staple food in Asia, which accounts for about half of the world's population. The common method of controlling rodent pests in these three countries is through the use of chemical rodenticides which are known to be harmful to human, animals, and the environment. As an alternative to rodenticides, ecologically-based rodent management (EBRM) was developed by the Australian Center for International Agricultural Research (ACIAR) in partnership with the national agricultural research and extension system (NARES) of each host country (*Singleton et al. 1999*). In total, ACIAR has invested more than US$4 million on rodent research with additional contributions, in cash and in kind, equivalent to US$3 M from commissioned and collaborating organizations.

The EBRM is an approach that combines cultural and physical rodent management practices. These include synchrony of rice cropping; implementing short two-week campaigns on rodent control at key periods such as one week before transplanting and within two weeks after transplanting; reducing the width of irrigation banks in fields to less than 30 cm to prevent nesting by rodents; improving general hygiene around villages and village gardens; promoting synchronous fallow; and demonstrating the use of community trap barrier system or CTBS (*Singleton et al. 2005*; *Brown 2006*).

Most importantly, EBRM requires a holistic system through community action participated by the whole community (not just farmers) to carry out these rodent management strategies that may or may not include aCTBS component. The CTBS entails the establishment of an early planted 'trap crop' to lure rodents to the traps, which ideally

should be put in place in surrounding rice fields approximately 2 weeks before the trap crop is planted. The trap crop is usually 20 × 20 m, surrounded by a plastic barrier that has at least one multiple-capture live-trap along each side. Each trap has an entry point for rodents leading directly into it and are monitored daily for trapped rodents. The CTBS provides a 'halo effect', reducing rodent damage in an area of 10–15 ha (*Singleton et al. 1999*). One distinct advantage of CTBS is that it does not use poisons, although management and labor costs may be higher than for typical baiting systems. Results of the EBRM research undertakings have been disseminated in the Mekong Delta Region as one of the benign approach to the persistent rodent pest problem (*Rejesus et al. 2014*; *Palis et al. 2010*; *Adam 2014*). However, despite the significant investment, little was known about EBRM adoption, and the impacts of such adoption on the farming community.

Objectives

This study aims to analyze the adoption and impacts of EBRM among rice farmers in Cambodia, Lao PDR, and Vietnam. It further looks into the facilitating and constraining factors of EBRM adoption, and the lessons learned that could guide EBRM implementation in the future.

Analytical Framework

The analysis followed the basic impact pathway framework (**Figure 1**) of *Templeton* (*2006*) which has been shown to be a useful evaluation tool (*Davis et al. 2008*; *Templeton and Jamora 2010*; *Walker et al. 2008*; *Rejesus et al. 2014*). The impact pathway framework is linked to broader discussions on 'theory of change' approaches where projects are viewed as potential transformational instruments to cause change. Impact pathways trace the pathway to change from the inputs (research project and activities) to research outputs (the deliverables), to outcomes (use of the deliverables by the next and final users), to impact (the ultimate change in social, economic and/or environmental conditions that occurs with widespread adoption). While the simplified schematic representation is linear, in reality the pathway follows multiple channels over different time scales.

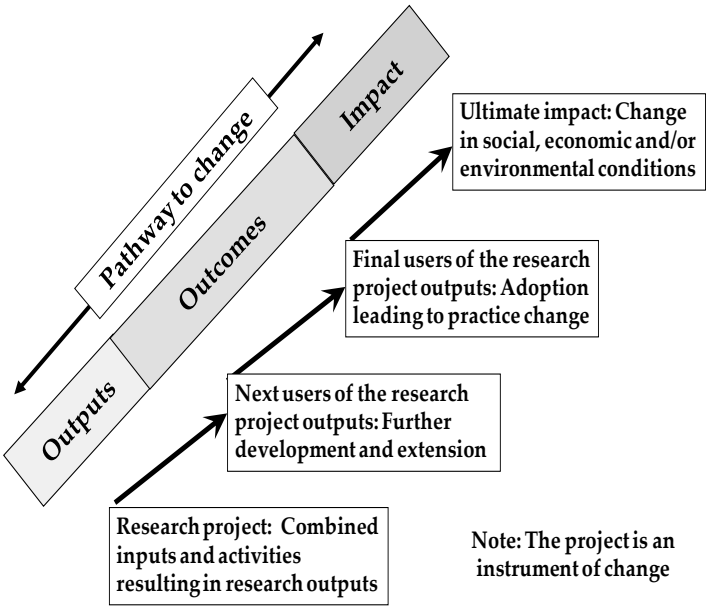

Figure 1. Impact pathway analytical framework (Source: *Templeton 2006*)

The inputs referred largely to the research projects, research investments (cash and in-kind) made by ACIAR and the collaborating organizations at different periods in the three countries and project activities in implementing the suite of rodent control projects. These investments and project activities produce the necessary outputs, the deliverables of the project such as technologies, knowledge and capacity built about EBRM. The outcomes refers to the utilization of the outputs by the users (i.e., level of adoption, mode of dissemination) and the immediate effects of the project on the users. The users are categorized as the next users and final users. The next users were the NARES in each country such as the Plant Protection Department (PPD) in Vietnam; National Agriculture and Forestry Research Institute (NAFRI) and National Agriculture and Forestry Research and Extension Centre (NAFREC) in Lao PDR; Cambodian Agricultural Research and Development Institute (CARDI) as well as the Office of Agricultural Extension (OAE), Cambodian Ministry of Agriculture; and NGOs such as the World Vision (WV) in Vietnam and Lao PDR, and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in Lao PDR. The final users were the rice farmers whose adoption of EBRM is expected to contribute to increase yield, lower production costs, higher farm income, and subsequently to produce the intended impacts. These impacts are the ultimate or longer-term effects of the project such as the improvement of their economic, environment, and social and cultural conditions.

Considering the numerous factors affecting the adoption of technology, the enabling and constraining factors for adoption and the challenges that arise also formed part of this study to guide EBRM implementation in the future and ensure and sustain EBRM adoption. The impact analysis was largely based from desk reviews especially from published scientific papers, and accounts of farmers and various stakeholders from the FGDs and KIIs during the evaluation field visits.

METHODOLOGY

Locale of the Study

The study covered 19 villages from the three countries distributed as follows: 8 in Vietnam; 4 in Cambodia and 7 in Lao PDR (**Figure 1** and **Table 1**). Most of the villages were study sites of the ACIAR rodent control projects and a few were non-study sites but nonetheless gave indication of

the extent of EBRM dissemination and adoption.

Methods for Data Collection

Data collection for the impact pathway analysis was undertaken in selected communes, villages, districts and provinces in the three countries: Vietnam, Lao PDR and Cambodia. Focus group discussions (FGDs), key informant interviews (KIIs), and review of project documents were conducted to assess the impact pathway of EBRM.

A desk review of the available documents on rodent control projects in each country was performed to gather the information related to the conceptualization, components and implementation of the projects. In addition to, all published and unpublished scientific papers that resulted from the ACIAR rodent control research undertaken in Vietnam, Cambodia, and Lao PDR were used to complete the picture of the impact pathways of all the projects. Quantitative data and analyses were largely based from these secondary sources.

Focus group discussions (FGDs) were conducted with 10–15 male and female farmers (the final users of the research outputs, **Table 1**) in each of the 19 villages covered in the study to assess the adoption/non-adoption of EBRM, and to gather information about farmers' experiences, problems and suggested courses of action for the sustainability of rodent control and management efforts.

KIIs were done among the next users of the EBRM that included the representatives of the local collaborating institutions of the rodent projects, extension workers, and NGO staff involved in the implementation of the projects. Key government informants included officials of NARES institutions at the national, provincial, and district levels of each country. Key NGO informants were the World Vision managers in Vietnam and Lao PDR, and a Lao PDR GIZ officer. KIIs were also done with the ACIAR Vietnam Country Manager, government local leaders and village farmer leaders. The purpose of the KIIs was to gain the perspectives of the informants on the adoption of EBRM and the impact pathways of rodent control projects, as well as their future plans for agricultural programs, particularly rodent management, in their respective countries.

RESULTS AND DISCUSSION

EBRM Projects Studied

Eight rodent control and management projects were implemented in the Mekong Delta Region. Six of them were implemented in Vietnam, where the first EBRM project was conducted in 1995 and the latest in 2009 (**Table 2**). The projects in Lao PDR and Cambodia came relatively later and were implemented based on the review and recommendations of the first two projects in Vietnam.

Projects Activities and Outputs

The common activities of the EBRM projects in the three countries were: capacity building, participatory research, production and distribution of training materials, annual project meetings, and dissemination activities i.e., training of farmers, group meetings. Capacity building included Training of Trainers (TOT), on-the-job training of the in-country project team (scientists and technicians) and more formal training. The TOT primarily focused on rodent biology, ecology of rice-field rodents, rodent control methods, taxonomy, and identification of rodent pests. Training workshops were also delivered to research staff and extension workers to equip them with the skills necessary to demonstrate and pilot the CTBS in the field and conducting community actions.

While building the knowledge and skills of the in-country and Australian scientists was essential for ensuring the technical outputs of the projects, the activities also left a legacy in terms of increasing the in-country capabilities in

Table 1. Distribution of villages covered by the study. Number of villages where focus group discussions were conducted, by country and province.

Country	Province	Number of Villages	Remarks
Cambodia	Kampong Cham	3	2 project treatment sites, 1 diffusion site (another district)
	Kampong Thom	1	1 diffusion site (another province)
Lao PDR	Luang Prabang	3	Project sites (2 treatments, 1 control)
	Luang Namtha	4	Project sites (2 treatments, 2 controls)
Vietnam			
Mekong Delta	An Giang	3	2 project treatment sites, 1 diffusion site (another district)
(southern Vietnam)	Soc Trang	1	Project treatment site
Red River Delta	Ha Nam	2	1 project treatment site, 1 diffusion site (same district)
(northern Vietnam)	Hung Yen	1	1 diffusion site (another province)
South-central	Bin Thuan	1	Project treatment site
Total		19	

Table 2. List of rodent control and management projects implemented in the Mekong Delta Region.

Project code	Project title	Collaborating country	Inclusive dates
AS1/1994/020	Management of rodent pests in Southeast Asia	Vietnam	1 January 1995-31 December 1998
AS1/1996/079	Management of rodent pests in Vietnam	Vietnam	1 July 1996-31 December 1998
AS1/1998/036	Management of rodent pests in rice-based farming systems in Southeast Asia	Vietnam and Lao PDR	1 January 1999-30 June 2003
AusAID: Capability Building for Agriculture and Rural Development (CARD) 2000/024	Enhancing capacity in rodent management in the Mekong Delta region using non-chemical methods	Vietnam	July 2000- mid October 2002
PLIA/2000/165	Facilitating farmer uptake of ACIAR project results: Component 4 – Rat control in rice-based farming systems	Vietnam	1 January 2001-31 December 2003
ADP/2003/060	Implementation of rodent management in intensive irrigated rice production systems In Indonesia and Vietnam	Vietnam	1 April 2006-30 March 2010
AS1/2004/016	A system approach to rodent management in upland environment in Lao PDR	Lao PDR	1 January 2005-31 December 2006
ASEM/2000/007	Farmer-based adaptive rodent management extension and research system in Cambodia	Cambodia	1 July 2001-30 June 2003

scientific research. Participatory research- local and foreign scientist with the farmers- was focused on demonstrations on the use of the community trap barrier system (CTBS), and at the same time on studying the rodent biology and ecology of rice field rats in respective country locations for the development of proper timing in doing community actions. Except in Vietnam, piloting the effectiveness of community action, both with and without CTBS, was also done. In Cambodia, an intern from the Australian Youth Ambassador for Development (AYAD) program assisted with the project, especially with rodent taxonomy. Also, periodic visits of University of Queensland and CSIRO experts to the project sites, meetings and workshops with CARDI and OAE staff.

In terms of formal training, some NAFRI staff from Lao PDR, attended a master class on rodent biology and management in IRRI, Philippines. In Vietnam, two PPD staff took their PhD on rodent biology and management; and one World Vision staff studied Masters in Development Studies in Australia. In Cambodia, one of the CARDI staff was sent to Australia for her PhD in Economics.

After the TOT of research and extension staff, dissemination activities were conducted. Dissemination activities included: training of farmers, group meetings, season long field demonstrations, visits of project staff and extension workers. Farmers were trained by extension workers on rodent biology, taxonomy and identification of rodent pest species and setting up and management of CTBS. Farmers were trained on how to determine the sex and age of rats by actual dissection of rats caught considering that EBRM- community action and/or CTBS- should be implemented at the early stage of the crop to prevent further increases in rodent population. Village campaigns through community action were conducted in Vietnam and Lao PDR but not in Cambodia; although the community action in Lao PDR was limited compared to Vietnam. The above mentioned project activities produced the project outputs which included: technical capacity built among research, extension workers and farmers involved in the project areas. These are in terms of: trainings conducted and research and extension staff trained on rodent biology, ecology, taxonomy, rodent pest identification, and management; extension workers and farmers knowledge on setting up and managing EBRM - CTBS and /or community action; farmers trained on EBRM; policy recommendations formulated for local, provincial or national recommendations for controlling rodents; and the locally suited EBRM which incorporated indigenous knowledge and practices consistent with the goals of sustainable agriculture. The EBRM developed in each country was adapted to local rice field environment and social and cultural conditions.

Outcomes: EBRM Adoption by Next Users

The locally adapted EBRM in the three countries were adopted by the research and extension staff of partner countries including staff from partner NGOs. The capacity built among these next users have increased their knowledge in addressing rodent problems, and consequently increased the number of government staff capable of implementing EBRM in respective country.

Vietnam

The next users- PPD staff and extension workers- have

Figure 2. Map showing EBRM project sites in Cambodia, Lao PDR, and Vietnam (Source: *Palis et al. 2013*).

increased understanding of the efficacy of the CTBS, and the biology and ecology of rodent pests, enabling them to pilot the use of CTBS and demonstrate it to participatory farmers. Mass strategic community actions for rodent population management were also conducted and mobilized through active linkages with local and national government institutions.

In addition, the Government of Vietnam used the policy recommendations about the locally adapted EBRM (community action alone with or without CTBS) to make a major policy change on rat control and management. From that, the Prime Minister issued policy no. 09-1998/ CT/TTG, which directed all provinces to adopt IRM-V or EBRM and establish farmer groups to control rodents, encouraging the farmers to use physical or cultural methods of rat control (*Office of the Prime Minister, Vietnam 1998*). Before this policy change, farmers relied heavily on the use of rodenticides. With this policy, rodent control groups of farmers were formed particularly from farmers' cooperatives in the North.

The EBRM implementation and national policy directive resulted to budget allocation for rodent management by respective provinces. For instance, the provincial government of Hai Phung allocated A$23,432–35,148 (VND 200–300 M) to rodent control from 1998 to 2000 fordissemination activities especially on CTBS demonstrations (*Palis et al. 2004*).

The improved knowledge of the staff at the national, provincial and district levels of the PPD and extension offices enabled them to integrate the EBRM modules into the Farmer Field School (FFS), the national extension program in Vietnam. The PPD, in collaboration with World Vision Vietnam (another next user), was also able to scale out EBRM to other districts and provinces. An example of this was the expansion of EBRM in three communes in Hung Yen province in the Red River Delta. The EBRM modules, particularly on community action, were also integrated in the 21 Area Development Programs (ADPs) of World Vision Vietnam (*Palis et al. 2011*).

Up-scaling was clearly evident in Vietnam, where MARD issued an order (official telegram no. 21/CD-BNN-BVTV on 'Strengthening prevention of rodents to protect crops') dated 8 November 2010 and the PPD a letter (no. 1676/ BVTV-TV) on 29 September 2010. These technically embodied the recommendations associated with EBRM from the earlier 1998 standing directive from the Prime Minister. The order directed MARD agencies to plan rat control for each period during the crop season, in cooperation with mass organizations in the local communities. Specifically, it prescribed community action with specified timing for each action, consistent with the recommendations of the ACIAR project. The order further directed specialized agencies to support the effort, including providing support to village organizations and cooperatives in the campaign to control rodents (*MARD 2010*). These directives led further to wide adoption of EBRM by next users- PPD staff and extension workers, and World Vision Vietnam- resulting to the wide implementation of EBRM in the country.

Lao PDR

The capacity-building activity of the project led to enhanced capability in NAFRI and the establishment of the National Rodent Management Laboratory. Another important outcome was realization that CTBS technology has limited application in upland shifting cultivation, due to limited water availability, changes of crop mixes, and the topography of the upland environment. However, the CTBS was found to be effective in reducing rodent-induced losses in grain storage areas.

The next users of the outputs of the project were researchers from NAFRI and extension officers from the Provincial Agriculture and Forestry Offices (PAFOs) and the District Agriculture and Forestry Offices (DAFOs). The results of the project, such as new knowledge about rodent behavior, and the manuals on rodent species and their control, were important inputs to their extension work, especially in introducing EBRM to farmers. Together with farmer leaders, who were also trained in rodent control, they passed on the knowledge to other farmers in the village.

Aid agencies, such as World Vision Laos and GIZ, were also next users of the project outputs. World Vision extended the technology to other districts in Luang Prabang. The GIZ included rodent control management in its training activities for World Vision's ADPs for farmers in several provinces of Laos. Such efforts broadened the opportunities for EBRM to be introduced as an option to the farmers.

Cambodia

The CARDI, a new institution at the time of the project, gained a good understanding of the rat population and conducted regular meetings with farmers. In this way, the staff members were exposed to dealing with farmers and gained the skills in working with the farming communities. OAE was also able to extend the use of the CTBS to other areas outside the pilot sites. One of the significant outcomes was the establishment of good communication between CARDI and OAE, something that was not present before the project. It also developed external linkages between CARDI and OAE and the institutions in Australia. CARDI and OAE, as the next users of the technology, also recognized the importance of rat management on a wider scale.

Outcomes: Adoption by Final Users

EBRM was adopted by farmers, the final users of the technology. However, the differences in the time of project introduction and period of implementation gave wide variations in the level of EBRM adoption in the three countries.

Vietnam

Except for CTBS, the other components of EBRM have been adopted in Vietnam. Before EBRM was implemented at the project sites, farmers in northern Vietnam used a variety of methods to control rodents, such as chemicals (99%), electrocution (2%) and several integrated methods including hunting and digging, trapping and water pumping (100%) (*Nga et al. 2009*; *Palis et al. 2011*). With EBRM, there was a significant change in rodent management practices of farmers, from heavy use of rodenticides to the practice of community action for rodent management. The involvement of farmers in integrated community actions doubled, from 36% in 2005 to 62% in 2009; rodenticide use decreased significantly (52% from 2005 to 2009 in project sites and 6% province-wide), electricity use disappeared andintegrated methods were continuously used (*Palis et al.2011*). Community actions were done two to four time in one season, especially during land preparation, transplanting, from 10 days after transplanting (DAT) to the maximum tillering stage (30–45 DAT), and at the booting stage. In 2009, all farmers participated in community actions during land preparation and transplanting for both the spring and summer seasons. At least 80% of the famers participated in the community actions carried out during the tillering and booting stages of rice production for both the spring and summer seasons.

The adoption of CTBS was also explored, even though its implementation was purely for demonstration purposes and was managed by the researchers. The CTBS was practiced only by the farmers contracted at the pilot sites; there was no adoption of the technology by other farmers. Constraints mentioned by farmers were: high investment cost, which included both monetary and transaction (time involved) costs; and difficulty in doing early planting, considering their small farm sizes (72.2% of respondents, *Palis et al. 2004*; *Palis et al. 2011*).

In Vietnam, the evidence of scaling out was also clear. Farmers from project areas, through the facilitation of the PPD, sub-PPDs and, in some instances, World Vision, shared their experiences with other farmers at non-project sites. The project reported a significant diffusion of EBRM in neighboring villages, districts and provinces. In 2009, all 11 districts in An Giang province and 152 cooperatives in Ha Nam province implemented community actions (*P. Brown, unpublished ACIAR annual project report 2009*; *Nga et al. 2009*; *Palis et al. 2011*). Scaling out was facilitated by village meetings, demonstrations and exchange field visits to other farms, where the use of rodent traps had been demonstrated at all project sites. The campaigns brought the technology into actual use and led to its village-wide adoption.

The diffusion of the technology was enabled by the combination of various modalities at all levels. Key to this was the role played by the local institutions, from the People's Committees to the Plant Protection Stations, sub-PPDs and PPD, their composite technical experts and extension workers, and the various farmer groups, including farmer associations and IPM clubs in the Mekong Delta and the farmer cooperatives and rodent control groups in the Red River Delta. Importantly, the national-level directives were the key impetus in the successful adoption and diffusion of EBRM in Vietnam. Local governments were obliged to allocate budget for EBRM implementation. Also, since EBRM has been incorporated in the FFS curriculum, the chance of it being continuously adopted remained high.

Lao PDR

Noticeable changes were recorded in the rodent control practices of farmers in the project sites in Lao PDR. The use of rodenticides in Lao PDR, during the project declined by 39% (*Brown and Khamphoukeo 2007, 2010*). According to the farmers, the adoption of community action and locally suited CTBS have reduced areas with rodent damage which led to an increase in crop yields concurring also to the findings

of *Brown and Khamphoukeo* (*2007* and *2010*). Community campaigns held were a bounty system wherein children were given school supplies according to the number of rodents caught. Although farmers saw the CTBS effectiveness when used in grain storage areas, the high investment in materials needed to set up CTBSs constrained their continued use of this specific rodent technology.

However, there was no evidence of scaling up of EBRM in Lao PDR. Although a policy exists on raising cats and the non-use of rodenticides at the village level, there are no specific directives from higher authorities. Consequently, more can be done in scaling up of the EBRM technology to strengthen the rodent management in Laos, since policy at the village level may change with the changes in local leadership.

Cambodia

Farmers at the project sites acquired greater knowledge of effective rodent management and became confident inselecting sites for the construction of CTBSs. However, the KIIs and FGDs conducted revealed that adoption was high only during the time the project was operating. The farmers admitted that, after the project, they were not able to continue using the CTBS due to the high cost of materials. In addition, the majority of farmers discontinued CTBS use after the monetary benefits of participating in the project stopped, with the villagers saying that they were busy with activities that were more important than rodent control.

Similar to Lao PDR, there was no evidence of scaling up of EBRM in Cambodia. According to farmers, the concept of community action was relatively new and they had some difficulty working as a group. It could be inferred that this was due to the historical experience that they had had with cooperatives. On the other hand, farmers admitted that since they now know the timing of rat control, working individually but concurrently will add value to collective rodent management. More importantly, farmers became aware of some other rodent control techniques, like modification of traps, which can stand alone and suit local conditions (*P. Brown, unpublished report 2003*). Although, the OAE was able to pilot the CTBS in another district, the farmers were reluctant to use it due to financial constraints.

Impacts

In Vietnam, EBRM has contributed to the community-level impacts, such as improved economic, environmental and social conditions. Farm-level economic impacts noted in the northern Vietnam were: a rice yield increase (9.4%), a reduction in rat-damaged area (93.5%), a reduction in rodenticide use (>50%), a reduction in yield losses due to rat damage (91.7%), and an increase in net returns (35%) (*Palis et al. 2010*; *Nga et al. 2009*; *Palis et al. 2011*). Although other factors may have contributed to the reduction in yield losses, farmers attributed the reduction to the better rodent management practices they had learned from the intensive training courses and guidelines on rodent management. Also, *Rejesus et al.* (*2014*) found that the improved economic welfare of farmers from EBRM adoption more than compensates for the research investments made to develop and/or disseminate it. They have estimated the rate of returns to total research investment of EBRM in Vietnam to a Benefit-Cost Ratio of 2.96.

In addition to changes in economic conditions, environmental benefits were also observed as a result of shifting from the use of chemical rodenticides and plastic fences to more environmentally friendly methods such as EBRM for controlling rodents (*Brown et al. 2010*; *Palis et al. 2011*). In terms of social and cultural impacts, working together for a common goal has led to a more cohesive interaction among the different sectors; namely, farmers, farmer leaders, political leaders, youth and women in thecommunity. These improvements in social cohesion offer the possibility of greater support for the continued use of EBRM. For example, *Brown et al.* (*2010*) and *Palis et al.* (*2011*) showed that there were also strong shifts toward the implementation of community actions, from 36 to 62% of famers in Ha Nam and from 5 to 11% in An Giang. Also, farmers' perspectives on rodent management has shifted from chemical use towards a biologically sustainable approach.

There was also a useful contribution to science and research as shown in a number of rodent projects generated in Vietnam. Further scientific impact is evident from the presentation of research results at conferences and the publication of papers in journals and books. The publication of these project results contributes to the existing body of literature about rodent control and management and is useful to students, practitioners and other researchers in this field.

In Lao PDR, community-level impacts of the project were limited in the project sites alone. According to farmers, *Brown and Khamphoukeo* (*2007 and 2010*), these impacts were increased crop harvest that led to increased income; improved environmental conditions that contributed to better human health; and stronger social cohesion. Systematic rodent control has lessened the damage to crops, giving farmers a much better harvest. Whereas before they regarded rodent pest damage as 'normal', they now appreciate the additional income they could have earned from the damaged crops. Supporting the drive against the use of chemicals for rodent control has also contributed to lessening the risks tothe environment. This, in turn, as perceived by farmers that it has contributed to promoting better human health.

In Cambodia, the results of the evaluation of the rodent

project in Cambodia by *Brown* (*unpublished report 2003*), and verified during field visits, indicate that the project had not made any significant impacts at the farmer and community levels. A 3-year period was not sufficient for the community to absorb the new technique for rodent management.

Factors Affecting Level of EBRM Adoption

The adoption of EBRM is a function of the interplay between enabling and constraining factors, which include political, historical and institutional, socio-economic, cultural, and other related ones.

Political, historical and institutional factors. Although Cambodia, Lao PDR, and Vietnam are similarly located in the Mekong River Delta, their political structures, histories, and institutional set ups differed to a certain extent. The political system in Vietnam enabled the adoption of EBRM through policy directives from the government, which included: The Prime Minister's policy pronouncement in 1998 directed all farmers to adopt integrated rodent management at the village level and to establish farmer groups to control rodents in each village; Another directive that gave impetus to rodent control was the government policy issued in 2008, during an outbreak of the brown planthopper, which mandated that all rice farmers practice synchronized planting- one of the components of EBRM; A letter from the Plant Protection Department (PPD) in September 2010 which invokes to continue the strict implementation of the Prime Minister's directive; and The Ministry of Agriculture and Rural Development (MARD) directive in November 2010 invoking the need to strengthen rodent prevention among the people's committee of provinces and cities to reduce the damages to the lowest level.

The government-issued order is a tacit recognition of the intricate web of institutional linkages and networks among the various levels of state agencies involved. It was recognized that a strong partnership between the government agricultural agencies, farmer groups, and local government units is an essential factor for adoption. Since the PPD is responsible for recommending or endorsing policies about crop protection to the central authority and to farmer groups, the implementation of government order was smooth and efficient.

Another key to successful adoption of the EBRM in Vietnam was the presence of local community groups. Foreach agricultural cooperative, there were sub-farmer groups such as the plant protection team and rodent control group. The plant protection team was responsible for monitoring insect and disease infestations and providing advice to farmers on pest control actions to take. The rodent control group was responsible for monitoring rodent damage and implementing rodent control actions. Together with the farmers' association, the sub-groups of the village people's committee worked together for community action in managing rodent problem.

The involvement of World Vision has contributed to the adoption and diffusion of EBRM by incorporating it in its areas of development in Vietnam. The capacity-building component of the World Vision has helped farmers to strengthen cooperatives that facilitated adoption of EBRM.

In Lao PDR, the different policy directions that could have influenced the adoption of technology included land allocation policy and government thrust, local resolutions, and village leadership. The laws and resolutions at the local level encouraging the raising of cats and banning the use of chemical rodenticides have provided the enabling factors for the villagers to adopt the rodent trap technology and other indigenous methods that are much safer than rodenticides. Farmers reported that cats can reduce rodent damage by 5-6%. However, the success of EBRM adoption largelydepends on the political will and leadership capacity of the village head. The village leader, being highly regarded by the community, also served as a role model for others in the village.

In Cambodia, farmers relied heavily on authorities or authority figures for decisions regarding field activities. Innovations are easily introduced if the person doing the introduction of a new technology is an authority figure. The farmers, as dictated by their culture, would cooperate. To sustain an activity at the community level, a strong and credible leader is essential. However, their bad experiences of working together in cooperatives from their recent history gave them a dislike for the word cooperative or collective action.

Socio-economic and cultural factors. The adoption of community action in Vietnam was facilitated by its compatibility with the communitarian attributes of Vietnamese society. Coordinated community action, born from the traditional commune system, is the norm rather than a novel concept in Vietnam. The Chinese influence of Confucianism, which is viewed as both a philosophy of life and as a religion, emphasizes the importance of loyalty, respect for authority, and peacefulness (*Quang, 2003*). Respect for social hierarchies is therefore basic to Vietnamese families and society. By far the most importantof these values are those associated with family and community, in which individual interest is subordinate, if not irrelevant, to the welfare of the whole group (*Muoi, 2002*). The experience of collective farming in the past has provided a strong foundation for effective collective action. Although this is more profound in the north, the concept is gradually evolving in the south as a result of unification. Hence, lower-level authorities and the people will adhere to a directive coming from higher authorities.

There was a cultural incentive to adopt non-chemical-based technologies in rodent management. This was not only to ensure that health of farmers and animals do not get exposed to the hazards of chemicals but also to keep a poison-free diet when they serve rodents on the table. The attractiveness of community activities was also enhanced by its compatibility with the cultural orientation of the Vietnamese toward merriment and camaraderie. Thus, the sense of community that was already in place in Vietnamese society strengthened community camaraderie and in turn facilitated the adoption of EBRM.

The CTBS, as earlier mentioned, may or may not be a necessary element of EBRM. In Lao PDR and Cambodia, CTBS was the main technology that was promoted and validated; although limited community action was also implemented in Lao PDR. Economic factor was a key consideration in the adoption of CTBS. In all three countries, the high investment cost in setting up CTBS along with high maintenance and transaction costs constrained its continued adoption, despite that it has been proven effective in controlling rodents,

Indigenous knowledge has provided logic to local adaptation of the technology. Farmers tended to innovate and divert from what was recommended. For example, adoption of technology was modified by the farmers' own pragmatic considerations, and may run counter to what was prescribed. In Vietnam, farmers pointed out that community action should be done only once, contrary to the prescribed frequency of two to three times per cropping season. They felt that there was no more need for it once rodents are gone in their fields.

In Lao PDR and in Cambodia, people have been used to having rodents and did not anymore perceive them as threat. The rodent problem has been rated second (after insects) among their production constraints (*Schiller, Buopha and Bounnaphol 1999*). In the uplands of Lao PDR, there was a prevailing thought that the rodent problem is something they have least control of (*Schiller et al. 1999*). Until this cultural mindset is addressed properly, it will remain a deterrent to the adoption of CTBS or any other improved technologies for rodent control in Lao PDR.

Lao PDR has more than 160 ethnic groups, each with its own identity and language (*King and van de Walle 2014*). The government policy of the merging of villages was tantamount to the merging of people from different ethnicgroups, and may have constrained the immediate community action from happening. The ecological landscape of the upland farming systems in northern Lao PDR also made it difficult for farmers to work together for rodent community action and more so for the use of CTBS.

In Cambodia, religious or supernatural beliefs influenced the adoption or rejection of a new technology. The belief of not harming animals or else a person will be that kind of animal in his/her next life or reincarnation has also influenced them not to catch or kill rodents. How such traditional beliefs may be addressed to facilitate the introduction and adoption of rodent control technology such as CTBS remains a challenge.

Lessons Learned

Adoption of any technology depends on various factors. Although the EBRM technology was reported to be superior compared with other known methods like chemical control, it needs to have a more holistic approach. The political, historical, institutional set up, socio-economic, and cultural conditions of the end users must also be considered to ensure adoption and facilitate scaling-up and scaling-out of any technology and achieve the intended impacts.

The project implementors must see to it that the technology fits in the socio-cultural and ecological landscape of the community. What works in one country may not necessarily work in other countries. Linkages among the national and local agencies with farmers are critical in the dissemination and continuous adoption of the technology. Local knowledge of the end users of the technology must not be overlooked. Project implementors should consider the indigenous knowledge and practices in the area and build upon them, instead of introducing an entirely new or different technology. And to ensure wide technology dissemination and sustained adoption of any technology by the farmers- the final users- at a national level, a focus on favorable policy changes need to be targeted as a policy outcome as shown in the Vietnam case.

CONCLUSION AND RECOMMENDATION

The length of exposure to ecologically based rodent management (EBRM) practices has a positive effect on uptake and hence, impact. Of the three countries, Vietnam had the largest number of projects (six) and the longest exposure (1995–2010) to rodent control and management activities. Laos had two projects (1999–2006), while Cambodia had just one (2001–2007) and the shortest experience with a rodent control project. These differences largely account for the varying levels of outputs, outcomes and impacts in each of the three countries.

The ACIAR rodent control projects have brought about widespread adoption and significant impacts of EBRM in Vietnam but were limited in Lao PDR and Cambodia. The interplay of political, socio-cultural, historical, and economic factors is critical in the adoption of EBRM and its sustainability. Hence, the successes and experiences in one

country cannot be easily transferred to other countries, due to the differences in these factors.

The national-level directives in Vietnam indicated sustained adoption of community action both by the next users and final users. Considering the political top-down system of Vietnam, coupled with their history and norms of collective action through agricultural cooperatives, there was swift and wide adoption of EBRM. In Lao PDR, future investments to EBRM adoption and its sustainability should include capacity building not only on the research and extension staff and village farmers but especially on the village leaders who is highly regarded by the village community. The same is true in Cambodia where farmers relied heavily on authorities or authority figures for their social and economic decisions. These authority figures include research and extension staff, government leaders, and village authorities with a strong and credible leadership. Hence, the successes and experiences in one country cannot be easily replicated in other countries due to the differences in the above mentioned factors.

The CTBS, as a component of EBRM, has a low acceptance level among farmers due to the high investment cost. Likewise, except in Vietnam, the concept of community action was barely introduced or adopted. This needs further sensitization of the intermediaries and the end users of EBRM, particularly on community action. Other environmentally friendly rodent control methods that are used by the farmers can be incorporated into EBRM.

For pathways and impacts, Vietnam appears to have progressed further than Cambodia and Laos. The pathway for Vietnam was facilitated by PPD, from the national down to the district level resulting to economic, environmental, social and cultural impacts. In Laos, the pathway was started by NAFRI and picked up by World Vision and GIZ. However, there is only little evidence of impacts at the moment. In Cambodia, CARDI and OAE have started the pathway but much remains to be done to establish its impact, where the rodent control projects can still be considered to be in their infancy.

To sustain the gains from ACIAR's investment in rodent control projects, the following actions are recommended for the future: Enhance government support for establishing the policy and promotion of a national extension program incorporating rodent control especially in especially in Laos and Cambodia. Adoption of technology takes a long time to be realized. In the case of Vietnam, it took 15 years to achieve the successful widespread adoption of EBRM; Sensitize and continue to educate the stakeholders. Unless the farmers, farmer intermediaries and villagers see the rodent problem as one that merits serious attention, i.e. requires sustained management, their motivation to attend to it will not be as high or as sustainable; Integrate EBRM into existing agriculture-related programs. Rodent control and management are just one part of crop protection extension activities. It would be more effective if rodent control and management were integrated into the existing agriculture programs, such as IPM/FFS curriculum in Vietnam. The integration could be strengthened further through policy directives like in Vietnam, from a higher authority such as the agriculture ministry, or the prime minister or president of the country; and Network with other local and foreign institutions or organizations to build a cadre of rodent experts. A project's efforts in capacity building will come to naught if, after a while, those trained in rodent control leave or transfer somewhere else. The presence of international NGOs and development agencies like World Vision and GIZ was a positive force in the adoption and scaling out of EBRM in some areas.

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