Farmer Field Schools in Thailand: History, Economics and Policy

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Preface

The urgency to explore new avenues of departing from a pesticide-based path in agriculture has been long recognised. For example, in 1997 the Thailand Development Research Institute (TDRI), the Department of Agricultural Extension (DOAE), the Food and Agricultural Organization of the United Nations (FAO) together with the University of Hannover, Germany conducted a workshop in Hua Hin, Thailand, to develop strategies that help to escape from the pesticide treadmill that has been taking over Thailand's agriculture. The workshop reached a consensus for the need to generate policy conditions and other direct government interventions that greatly facilitate the diffusion of Integrated Pest Management in the country.

One of the earlier measures to foster implementation of IPM was a project on Farmer Field Schools in Rice supported by FAO since 1992. The concept of Farmer Field Schools on Integrated Pest Management was developed with the aim to enable farmers to make better decisions based on a good understanding of their field situation rather having to rely on the often imprecise advise from external information sources like the pesticide dealers. Implementing Farmer Field School is an investment and mostly it is the public sector that provides the necessary funds. Since public funds are scarce and thus compete over alternative ends accountability has become a necessity. Impact assessment provides the necessary information to show administrators and decision makers in international donor organisations and national governments whether these investments were efficient or not. Impact assessment of FFS has proven to be complex because of methodological problems and a large diversity of impact parameters. Also, many of the past impact assessment studies have been conducted under the influence of different perspectives held by stakeholders on what constitutes impact. Another problem was the oftentimes-problematic databases that were used to conclude on the impact of FFS. Therefore, there was a need for a study that relied on a single, but in as much as possible, consistent database that would allow the conduction of a rigorous scientific analysis.

The papers presented in this book make an attempt to move in this direction. All the analysis presented relies on a unique set of panel data collected over a period of over four years in five pilot projects on FFS in rice in Thailand. While the book does not claim to be a guideline on how to do impact assessment of

FFS, it offers a good blend of analytical procedures covering the various aspects of impact.

It is hoped that the book will help to rationalize the sometimes overly emotional debate on the pros and cons of Farmer Field Schools in IPM in developing countries.

Hermann Waibel

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At the Institute of Development and Agricultural Economics, Faculty of Economics of the Leibniz University of Hannover we gratefully acknowledge the contributions of Mrs. Hildegard Garming in eliminating a number of inconsistencies in the draft version and for greatly improving the text in several of the chapters. Also we want to recognize the extremely helpful editorial assistance of Ms. Sabine Liebenehm for an excellent job in editing and formatting the document. Thanks are also extended to Mrs. Nause and Mr. Heinrichs who assured the smooth administrative process in printing the book and the continuous functioning of the institute's soft- and hardware system.
High appreciation is extended to the agencies who provided financial support for this research, namely the Department of Agricultural Extension in Thailand and the Global IPM Facility FAO in Rome.

The authors

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Acronyms

BAFFS	Biological Agriculture Farmer Field School
BCR	Benefit Cost Ratio
C-D	Cobb-Douglas
CGIAR	Consultative Group on International Agricultural Research
DD	Difference in Difference
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension
DREAM	Dynamic Research Evaluation for Management
EIQ	Environmental Impact Quotient
FAO	Food and Agriculture Orgnaisation
FFS	Farmer Field School
gtz	Gesellschaft für technische Zusammenarbeit
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
LZ	Lichtenberg & Zilberman
MVP	Marginal Value Product
NPV	Net Present Value
PPSU	Plant Protection Service Units
ROW	Rest of the World
TDRI	Thailand Development and Research Institute

1 The Evolution of IPM Policy and Farmer Field Schools in Thailand

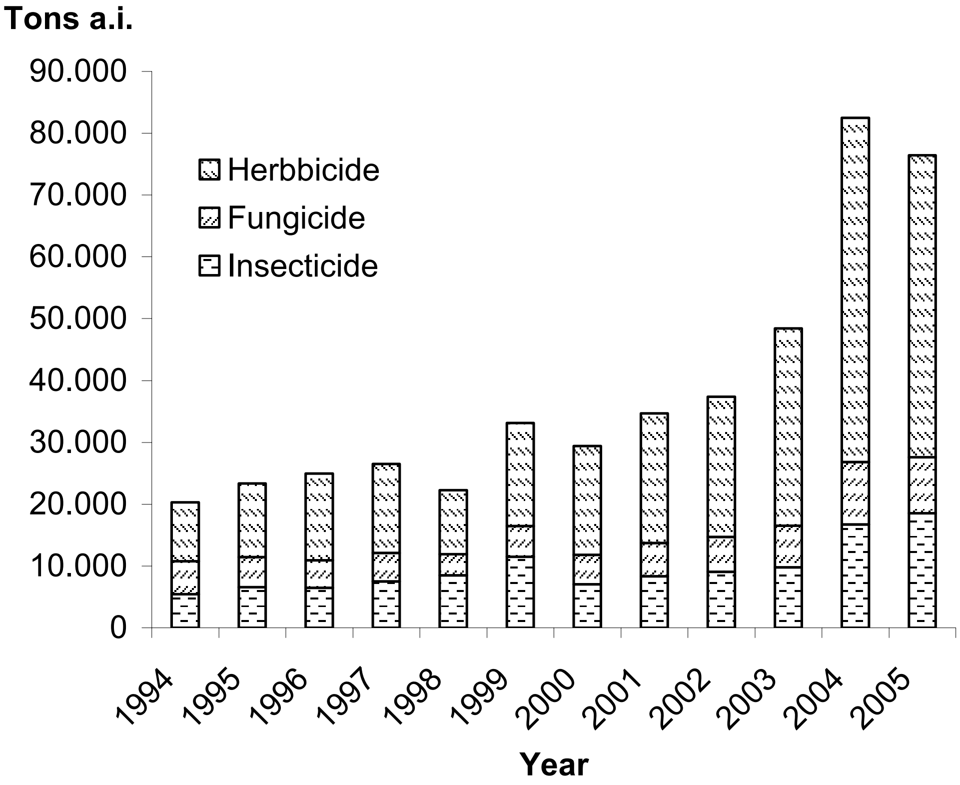
This chapter describes the how pesticide policy in Thailand has evolved together with the introduction of the green revolution in Thai agriculture. It begins with a brief analysis how government agencies in agriculture have tried to manage pest outbreaks by applying a command and control philosophy, and then analyses why this strategy has failed and how it has opened at least the opportunity for trying out a farmer-based approach to pest management.

The influence of government in crop protection in Thailand started in the early 1950s with the establishment of the crop protection section at the Department of Agriculture (DOA) under the Ministry of Agriculture. During that time agricultural pests were considered to be a “public bad” that required the provision of pest control services to farmers as a public good. The influence of the government was facilitated by the development of chemical pesticides, which were adopted in Thai agriculture rapidly. During that time the role of farmers in pest control basically was to carry out the instructions of the government pest control officers during the pest control campaigns. The DOA had been given the responsibility for pest control in all field crops except rice. During this period, the major pests in field crops were locusts of the *Patanga succincta species*, which mainly affected upland crops like maize. One reason for the increase of locust populations leading to severe crop losses was considered to be linked to the effects of expanding agricultural land for maize cultivation through deforestation. Furthermore, in maize monoculture favourable conditions for locust breeding grounds were provided while the ecosystem was disturbed resulting in a reduced capacity for natural pest control.

During that time, rice being the strategically most important crop, was under the responsibility of the Rice Department that had a rice protection section with expertise on the control of rice pests. In 1970 the department was merged with the DOA, which also marked the separation of agricultural research and extension. The responsibility of pest control actions was now given to the Department of Agricultural Extension (DOAE). Pest control measures, to combat large-scale pest outbreaks were mainly carried out by aerial spraying of organchlorine pesticides like Aldrin and Dieldrin. At that time the short term benefits from rapid and effective pest control were given priority over the negative environmental effects resulting from the high persistency of these compounds.

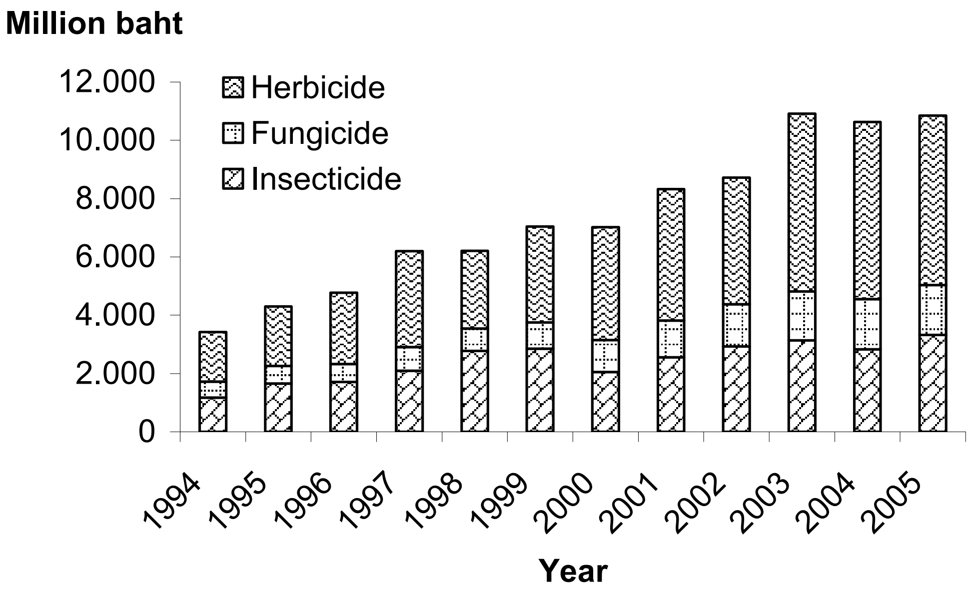
In rice, the "green revolution technology" was introduced since the 1970s with the crossbreeding of Thai rice varieties with germplasm from the International Rice Research Institute (IRRI). With the introduction of high yielding varieties the use of high levels of external inputs became profitable. The new varieties were photosensitive, which allowed their year-round cultivation. The change of the traditional multiple cropping systems in Thailand towards monoculture affected the agro-ecosystem's balance of pests and their natural enemies and provided more favourable conditions for the development of pests. In addition, the first of the new varieties were not specifically bred for pest and disease resistance, resulting in an increasing intensity of the outbreak of rice pests and diseases. In 1972 and in 1977 two major outbreaks of the tungro virus caused significant yield losses. Control measures at that time relied heavily on vector control through the use carbamate insecticides against the green leafhopper, *Nephotettix spp*. However, this control method was of limited success because the spraying of non-systemic, contact insecticides against an insect that was residing under the thick canopy of the rice plant was largely ineffective. Also the pesticide use in had severe side effects on the beneficial organisms in the rice ecosystem thus further reducing the capacity of the rice ecosystem for natural control. Overall, the use of pesticides has increased considerably both in terms of quantity and value during the past decade (see Figure 1.1 and 1.2)

Figure 1.1: Quantity of pesticide imports in of tons active ingredient.



Source: DOA, 2006

Figure 1.2: Value of pesticide use in Thailand, 1994-2005.



Source: DOA, 2006

The rice breeding strategy with emphasis on "vertical resistance" against major pests further enhanced the dependence on chemical pesticides. Due to the high selection pressure, new pest biotypes developed and quickly overcame the crop's resistance against pests. Panic reactions of farmers and of the government to pest outbreaks often further augmented the problem. Farmers were desperately applying higher amounts of pesticides and likewise the government through its crop protection service of the DOAE was distributing chemicals free of charge. Economic losses of pest outbreaks were perceived dramatically high, often without empirical evidence. Based on the perceived pest damage, the government introduced a policy of an emergency budget for storing pesticides to be managed by the 24 Plant Protection Service Units (PPSU) of the DOAE throughout the country. The procedure of the DOAE to purchase a stock of chemical pesticides on a preventive basis for combating pest outbreaks suffered from the inability to correctly predict the kind of pesticides that were actually needed. Also there was an incentive for those involved in the official purchase of pesticides to purchase low quality products at overrated prices. Hence, in many cases wrong and poor quality products were distributed. This contributed to the problem of resurgence of the green leafhopper and the development of new pests like the brown plant hopper, *Nilaparvata lugens*.

Furthermore, the system of government-managed pesticide dole out established an incentive mechanism for government officials in the agricultural service to exhaust and consequently replenish the outbreak budget on an annual basis. The system was thus prone to rent seeking behaviour of the various decision-making levels involved in the process of administering pesticide purchases. In this context pest outbreaks were a useful tool of supplementary income for agricultural service organisation personnel because on the one hand they were blamed for the failure of the sometimes technically faulty control measures (e.g. spraying pesticides below the rice canopy) and on the other hand they were misused by the government as an excuse for an ineffective subsidy policy (e.g. sustaining the outbreak budget as described below).

The programme of pest surveillance established by the Thai government in 1982, and supported by the Government of Germany through a technical cooperation project until 1989 with a total budget of about $ 6 million, aimed to strengthen the government's role to put in place an effective monitoring system for improving the government's capability for pest control decision-making. Surveillance was effective in prolonging the control of government agencies in the field of pest control and thus preserved the weak position of the farmers. The philosophy of the surveillance programme was counteractive to the FAO Inter-country programme for IPM in rice in Asia. The FAO programme had started introducing Farmer Field Schools in Indonesia during the early eighties. Largely because of the significant financial support extended by the Thai German Pest Surveillance Programme Thailand initially had rejected the FFS concept. Clearly, the FFS concept ran counter to the vested interests of a pesticide-based and government controlled pest control system, while on the other hand the surveillance programme offered an excellent opportunity for "pseudo-scientific justifications" of a centrally based pest control decision-making. For example, in 1989 a major brown plant hopper outbreak occurred. The outbreak was probably the result of a misguided response to prior increases in the price of rice, which prompted farmers to increase their pesticide use thus causing resurgence of the brown plant hopper. The government's reaction was equally misguided: it extended the outbreak budget for purchasing pesticides and distributing them to farmers free of charge to about $ 20 million during the outbreak period. This amount not only marked a significant increase of the insecticide market in that year but it also contributed to the legendary pesticide treadmill described in the crop protection literature earlier for many other countries (van den Bosch 1969). As more pesticides were sprayed the pest situation worsened, a phenomena that had been earlier observed for Indonesia (Kenmore 1996). The additional load of pesticides in rice also caused significant negative environmental and health externalities as summarized by Jungbluth (1994). In the proceeding years the discussion on the role of pesticide subsidies in developing countries intensified. Robert Repetto of the World Resources Institute in 1985 had written an article (Repetto 1985) that showed how pesticide price subsidies altered the economics of pest control in favour of high levels of pesticides leading to negative environmental effects and economic loss to the society. A paper published in the FAO Plant Protection Bulletin (Waibel 1990) illustrated the various types of pesticides subsidies and the different market-based as well as institutional disincentives to the adoption of Integrated Pest Management that particularly existed in Thailand. The paper provided a policy framework for assessing the types of pesticide subsidies and the analysis of the effects of the constraints to IPM adoption. The availability of an analytical framework prompted the Deutsche Gesellschaft of Technical Cooperation (gtz) to launch a global pesticide policy project to be administered by the University of Hannover. The project further advanced the policy framework to analyse pesticide subsidies (Agne *et al.,* 1995) and conducted studies in four countries that included an analysis of the existing pesticide subsidies and their implications for pesticide use and the lack of IPM adoption. One of the country studies was carried out in Thailand (Jungbluth 1996) that provided a comprehensive description of the complex system of disincentives for reducing pesticides use levels towards a social optimum and an estimate of the annual amount of external costs resulting from pesticides in Thailand. The project was carried out in collaboration between the University of Hannover in Germany, the Thailand Development and Research Institute (TDRI) and the Department of Agriculture (DOA) in Thailand. The major milestone of the project was an international workshop of pesticide policies carried out in 1997 in Hua Hin, Thailand. The policy meeting, which was also reported by the Thai TV channel 9, brought together some sixty international pest management and policy experts from multi- and bilateral development agencies, researchers, private sector representatives, high level policy makers and NGO representatives in Thailand. A series of high quality analytical papers on topics like pesticide subsidies and policy instruments had been prepared and were presented at the workshop. Furthermore, a thorough discussion of the alternatives to the existing patronage system in plant protection in Thailand with pesticide ‘dole outs’ and the prevailing rent seeking-inducing pest outbreak pesticide budget took place. One of the major recommendations of the policy workshop was to reduce the pesticide outbreak budget on the short term and reallocate the budget for farmer training in IPM while phasing it out altogether on the longer term (Poapongsakorn *et al*., 1999).

While there was no immediate decision in response to the policy workshop to revise the existing pesticide policy, the mounting evidence about the inefficiency of the institutional mechanisms crop protection in Thailand had also stimulated some discussion within the Department of Agricultural Extension (DOAE). DOAE was the government organisation within agriculture that benefited the most from the existence of a pesticide-oriented policy. Increasingly, IPM experts within the department questioned the utility of existing procedures of providing pesticides to farmer. This discussion was further fuelled by the initiative of the FAO Inter country Programme on IPM in Rice. In 1992, the FAO supported the Government of Thailand to start Farmer Field Schools in Rice. Initially, a total of only four FFS were established in the provinces of Chachoengsao, Chainat, Supanburi and Khon Kaen using the FAO FFS manual as starting-up guideline and gradually adjusting the procedure to make it compatible with the socio-economic and cultural conditions in Thailand. For example, in Thailand average farm size is bigger than in many other Asian countries and farmers often hire labourers for different farm activities. Hence, it was necessary to emphasize that in the selection of FFS participants the actual farm decision-maker participated in the training. Since for such participants the opportunity costs of time are high, more flexibility was required in scheduling the training. Furthermore, stringent government procedures did not always permit the facilitator training to be conducted as a full-time activity as intended by the originators of the concept.

It is also important to note that the official position of the DOAE at that time was not in support of the FFS programme. Consequently, implementation was slow and no up scaling of the programme took place during these years (see table 1).

Faced with a lack of policy support FFS in Thailand remained a solely donor driven activity and FAO closed down its support for this programme in 1998.

Ultimately, the withdrawal of FAO support would have marked the end of Farmer Field Schools in Thailand if not for the occurrence of a “lucky” event: Mr. Chanuan Ratanawarha, an Inspector General at the Ministry of Agriculture who was among the few higher-level policy advisors within agriculture was convinced of value of the FFS concept. He thus initiated substantial publicity for the programme. He was able to draw interest from the Thai TV channel 11. The TV station produced a film featuring the farmers’ activities in an IPM field school in the province of Sing Buri. The broadcast of the 40 minutes video impressively demonstrated to the general public the ability of farmers with low levels of formal education to prevent pest outbreaks with a minimum amount of pesticides without the help of the government plant protection service. Another important message was that farmers who sprayed less pesticides even had higher yields than farmers in neighbouring village who used higher levels of pesticides. The key turning point for FFS in Thailand was brought about by the fact that the “FFS film” came to the attention of King of Thailand, himself always an active promoter of sustainable development in his country. The King immediately recognized the larger implications of the FFS concept as a strategy of empowerment of the rural population in Thailand. Responding to the film, the King ordered a letter to be send to the Ministry of Agriculture were His Majesty strongly recommended the FFS concept for implementation throughout the country. The suggestion from the King was the trigger for policy change: The DOAE decided to abolish the outbreak budget and reallocated some 15 % of the 200 million Baht per year for FFS training. Hence the royal intervention triggered policy change, which finally led to the adoption of the earlier policy recommendation. The change in pesticide policy also resulted in further organisational and institutional change. An Institute of Biological Agriculture and Farmer Field School (BAFFS) was established within DOAE central office (headed by the author of this chapter) together with 9 BAFFS centers across the country. The BAFFS was given the responsibility to coordinate the implementation of a nation-wide FFS programme as recommended by the King of Thailand. In the following years the number of FFS increased reaching a total of over 800 in rice and even more in vegetables (see Table 1.1). However with the change in leadership at the DOAE priorities were again reversed towards a pesticide-based crop protection in Thai agriculture and the FFS programme declined.

Table 1.1: Farmer Field School Training Activities in Thailand, 1999 – 2006, Rice and Vegetables.

Regions	Rice			Vegetables		
	TOT	Facilitator	FFS	TOT	Facilitator	FFS
North	2	47	160	5	203	710
South	1	34	170		14	70
North-East	2	39	200	1	13	65
East		14	70		23	40
West	1	17	85	3	21	105
Central	2	25	135		8	40
Total	8	176	810	9	282	1030

TOT = training of Trainers

To date, while the FFS concept is still mentioned in the DOAE policy procedures, actual support in terms of budget and programming is minimal. In 2003 another reorganization of the DOAE took place and the BAFFS was dissolved and the FFS programme was placed under the responsibility of the pest management division of DOAE. Hence, the FFS concept lost its special status, which it had obtained during the time period following the King's intervention. In effect the wider implications of the recent reorganisation of the DOAE for FFS could be that the role of farmers as partners in the agricultural development process is given lesser priority again. While the outbreak budget has been abolished the general perception is that it could come back. This would mean that farmers will no longer be recognized by agricultural officials as empowered partners with an ability to conduct own collective pest control actions at minimal public sector interference. A backward-looking policy could be driven by vested interests of those groups, which benefit from a subsidy system.

Following this brief history of FFS in Thailand together with a glance of the policy background for IPM in agriculture in Thailand in the next chapters various aspects of Thailand's Farmer Field School programme will be presented using data from a pilot project and some evidence of its impact will be established.

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2 Study Area Description and Data Collection Method

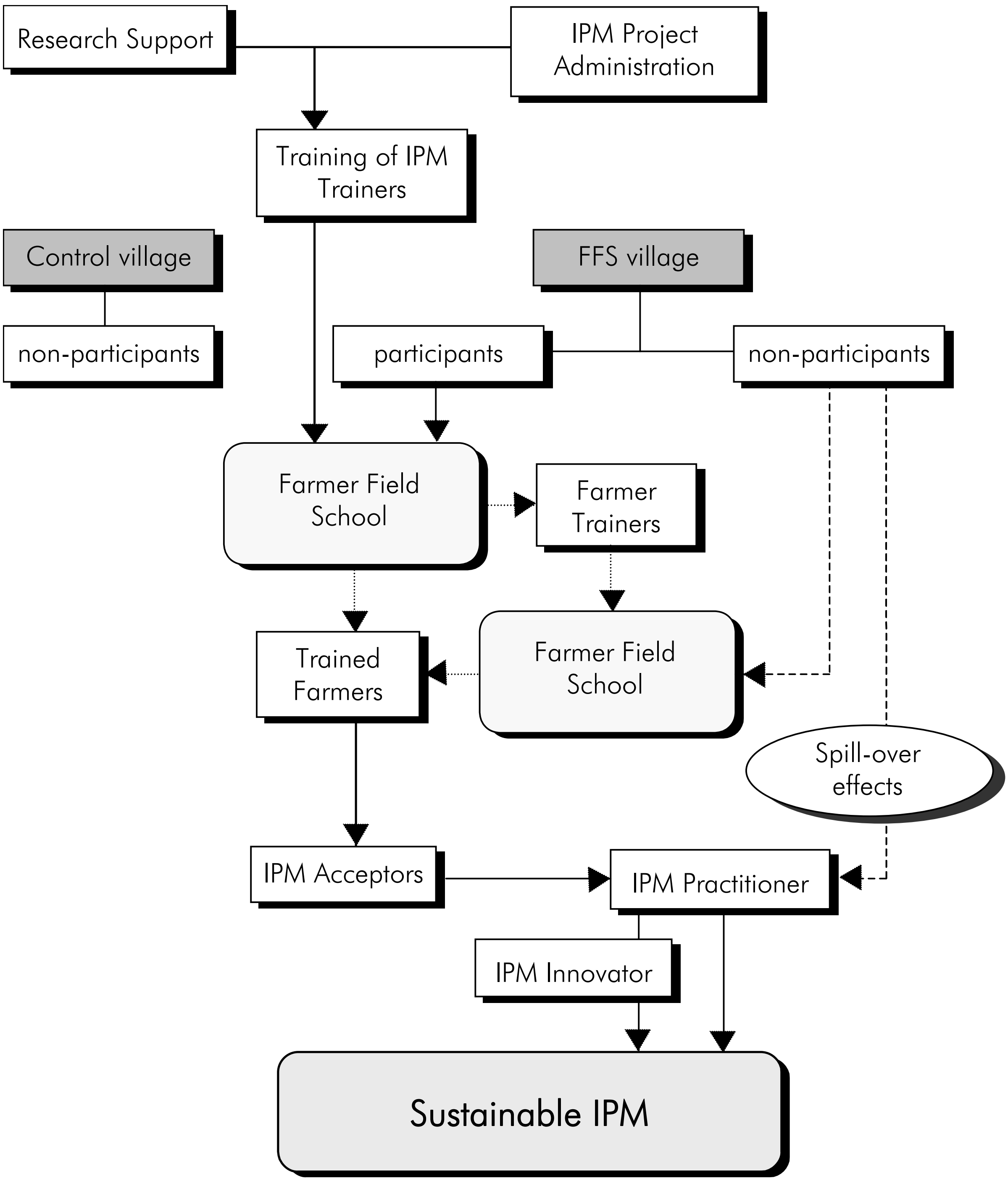
The Institute of Biological Agriculture and Farmer Field School (BAFFS) under the Department of Agricultural Extension (DOAE) coordinated the implementation of a nation-wide Farmer Field School Programme. It was launched as a pilot project of the National Integrated Pest Management (IPM) programme. The project started about 50 Farmer Field Schools (FFS) throughout the country. The target was to establish one FFS per Province in areas with irrigated rice farming. The programme was launched, during the cropping season 1999/2000.

In Figure 1 the general concept of FFS projects is shown. The agroecoystems principles are established through research support. For example, rice research has shown that in rice production in Asia insecticides are only rarely needed if farmers make conscious management decisions to augment beneficial insects as spiders and lady beetles can keep rice pest under control in most cases. For the purpose of farmer training in FFS specific guidelines are prepared which are used by the project administration to implement the concept. Unlike in many other countries, e.g. Indonesia, Vietnam and others in the case of Thailand, project implementation was not carried out by a foreign-supported multilateral or bilateral donor. Instead, the project administration for FFS was the BAFFS and budgetary support was from national funding sources. As a first step BAFFS organized the training of IPM trainers (see chapter 1). Part of their training is the conduct of an FFS with farmers selected to participate in a season long training. Often these farmers are not representative of all the farmers in the village since voluntary cooperation is a precondition for the training. Ideally, at the end of the training season there will be one or two farmers who will have the qualification to become a trainer also. They are called Farmer trainers (see Figure 2.1). Farmer trainers are supposed to undertake their own field schools in the same village or in neighbouring villages with some support of the extension department thus establishing a kind of semi-private training and extension service.

The hypothesis is that farmers who have successfully undergone the training will accept IPM principles and in the end change their practices. Some of them may also enhance their innovative capacity and further develop IPM principles on their own. Sustainable IPM is established if farmers maintain the new practices and continuously adapt their management practices to the new technology following these principles.

In impact assessment, these effects can only be captured with repeated surveys over a longer period of time. In this project data was collected at three different points in time. For the purpose of impact assessment a control village with similar socioeconomic characteristics is needed as well. While the major changes in attitudes and practices are expected among the trained farmers it is also possible that some changes occur (spill over effects) among those farmers who live in the same village but who did not have a chance to be trained. These are the “non-participants” in Figure 2.1. It is important to include this group in impact assessment because the gains that this group achieves are attributable to the FFS training.

Figure 2.1: The Farmer Field School Concept in IPM



Source: Fleischer *et al*., 1999

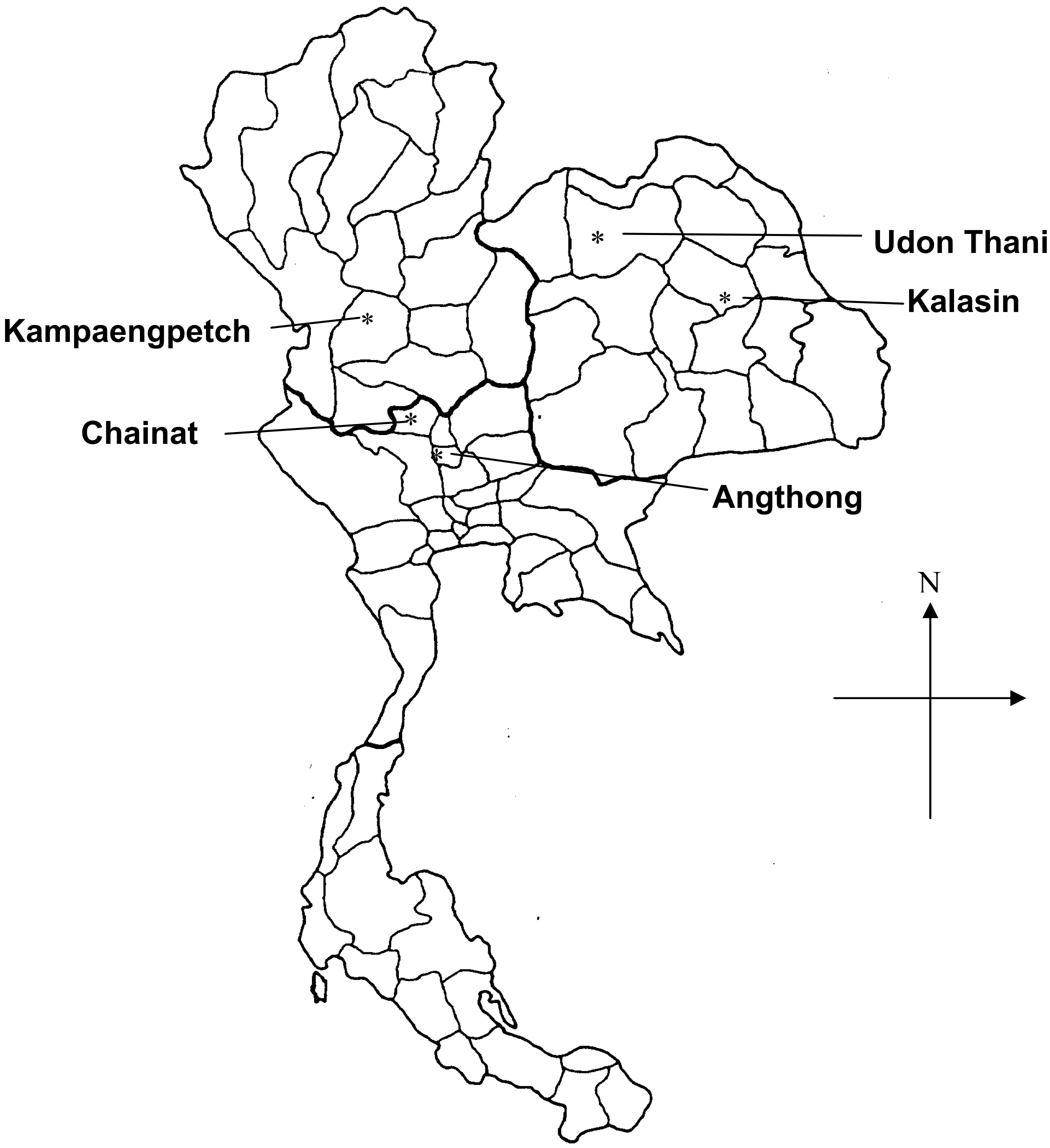
2.1 Study Area

For the impact assessment component of the project five out of the 50 FFS were selected for the economic analysis of IPM-FFS (Figure 2.2).

Five major rice producing provinces, Angthong, Chainat, Kampaengpetch, Udon Thani and Kalasin provinces (see Map below), were included. The selection of the provinces was based on the following criteria:

1. Major rice cultivation regions of Thailand; these are the Central Plains, the North and North-Eastern Region of Thailand.
2. Good performance of the trainer. Based on that two provinces were chosen as per judgment of the Director of BAFFS.
3. The provinces Angthong and Chainat were choosen as representative of the Central Plains. Udon Thani and Kalasin provinces were typical for the North-Eastern region. Initially, Kampaengpetch and Nakorn Sawan provinces were selected for their representativeness of the Northern region. Unfortunately, the IPM-FFS school in Nakorn Sawan had to be abandoned because the trainer had been re-assign for different work. Hence, five IPM-FFS schools were included in the impact assessment .

Figure 2.2: Locations of Pilot Projects.



Note: * indicates the selected province for the survey

2.2 Data Collection

Data were collected in five pilot sites mentioned above. In each pilot site a Farmer Field School following the usual methodology with a season long experiential training in the field (Kenmore 1996) was implemented. The sample included 241 farmers and was composed of three groups of farmers:

(1) training participants (FFS farmers), on average 20 farmers per FFS;

(2) 15 exposed farmers, per FFS village (non FFS);

(3) 15 unexposed farmers, randomly selected from a control village located near-by a FFS village (control farmers).

The control villages had similar socio-economic and natural production conditions but only a minimal possibility of information exchange with the respective FFS village existed.

The farmers were interviewed at three different points of time:

(1) in February 2000 at the end of the wet rice-cropping season, which was before the training had started

(2) in February 2001, in the rice growing the season after the training, i.e. where farmers could apply their new knowledge for the first time and

(3) in February 2003, two years after the second survey.

Thus, trained farmers had the opportunity to apply their new knowledge in four to eight rice growing seasons after the training, depending on the intensity of rice production, which varied in the five pilot villages. Unfortunately for the third survey the sample size had to be reduced because of heavy flooding in two FFS villages. Hence, the cases had to be reduced to 122 for the longer-term impact (Table 2.1).

Primary data was collected by interviewing the same farmers using a standardized questionnaire for all of the three surveys.

Table 2.1: Number of farmers interviewed before and after the FFS training.

Region/Province	FFS group	Non-FFS group	Control group	Total
Central Plain				
Chai-Nat	13	14	15	42
Angthong	23	12	15	50
North				
Kampangpetch	23	14	15	52
North-East				
Kalasin	34	10	15	59
Udonthani	14	8	16	38
Total	107	58	76	241

Notes: FFS = farmers who participated in the farmer field school.
Non-FFS = farmers who did not participate in the program but live in the same village as FFS.
Control = farmers in a non-program village with similar conditions as the FFS village.

The actual number of farmers participating in the field school varied and there were some participants who were not available for interview for the second survey. Respondents were interviewed with regards to their socioeconomic background, farm resources, institutional conditions, farm and off-farm activities, decision making processes and on rice production inputs and outputs. Also, information on farm household characteristics, farmer' crop and pest management knowledge, attitudes and practices and questions on health issues related to pesticide use was included. Particular emphasis was given to a detailed account of pesticide use regarding quantity, common and brand name, active ingredients and formulation.

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3 The Productivity of Pesticide Use in Rice Production of Thailand: A Damage Control Approach[1]

3.1 Introduction

Pesticides continue to be applied at high rates in Asian rice production. Such practice is contrary to research findings especially with regards to insect control where several researchers have shown that high levels of insecticide use are not justified from an economic point of view (e.g. Herdt *et al*., 1984). Simulation studies based on pest observations from farmer trials showed that in fact insecticides may only be needed in exceptional years (Waibel 1986). Studies referring to data from the Pest Surveillance Services in the Philippines and Thailand showed that the probability of the marginal revenue from insecticide treatments to exceed the costs of control is lower than 0.2 (Waibel and Engelhardt 1988). Rola and Pingali (1993), using a stochastic production function model that included human health effects of pesticides found that even in intensive irrigated rice, insecticide use is uneconomical altogether if health costs are included. Despite this evidence, to date farmers in many Asia countries still continue to spray two to three times per season on average (Heong *et al*., 1997, Horstkotte-Wesseler 1999). Agricultural policies that stimulate pesticide use through a number of hidden and indirect subsidies may impede the diffusion of Integrated Pest Management (IPM) whose adoption rates have remained below expectations (Waibel 1990, Jungbluth 1996, Poapongsakorn *et al*., 1999). Some doubts have been raised whether the popular and on a pilot-scale quite successful Farmer Field School approach to IPM is feasible for an up-scaling to a national level program (Quizon *et al*., 2001, CGIAR 2000).

One of the weaknesses of previous economic studies dealing with the productivity of pesticide use in rice is related to the methodology used in these studies. Overwhelmingly, in these studies either a production function or a partial budget approach was used. Applying partial budgets, the problem is

1 An earlier version of the paper was presented at the international symposium on "Sustaining Food Security and Managing Natural Resources in Southeast Asia: Challenges for the 21st Century, January 8-11, 2002 at Chiang Mai, Thailand. Paper was published in: *Thailand Journal of Agricultural Economics*, (2003) Vol 22, No. 2, p. 73 – 87.

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that here the economics of pesticides depends on pre-determined treatments in experiments. These may not always reflect farmer's actual practices and such trials are often not available over a sufficiently long period of time. On the other hand, production function analysis that treats pesticides as a yield-increasing variable ignores their true nature as damage abatement agents. As shown in previous studies this can lead to serious misspecifications of the effects of pesticides (Lichtenberg and Zilberman 1986; Carrasco-Tauber and Moffit 1992). Ignoring the true biological relationships in the standard production function, such as Cobb-Douglas, has consistently led to the result that conventional production function analysis leads to an overestimation of the marginal physical product of pesticides (Saha, Shumway and Havenner 1997, Ajayi 2000). Such overestimates in combination with the perceived risk-reducing nature of pesticides have resulted in a continuous high use of chemical pesticides in many crops including rice. Consequently, negative effects such as health and environmental hazards of pesticides have become a widely recognized problem. Therefore, it is important to accurately assess the productivity effects of pesticides applying an appropriate methodology.

This chapter examines the productivity of insecticides use in rice production in two regions of Thailand. The methodology is based on four alternative damage control specifications in the production function using survey data of 241 farmers across five provinces. The regression results are used to derive the marginal productivity of insecticides and assess the possible degree of insecticides overuse in rice production in Thailand

3.2 Theoretical Framework and Methodology

3.2.1 Theory of pesticide productivity

The methodology used for the economic assessment of pesticide productivity has made important advancements over the last decades. Initially, economists treated pesticides in a conventional production function framework, i.e. assuming them to be yield increasing factors like e.g. nitrogen fertilizer. Using a Cobb Douglas (C-D) function framework Headley (1968) estimated the marginal productivity of aggregated pesticide use in US agriculture for the period from 1955 to 1963. He found that the marginal value of a one-dollar expenditure for chemical pesticides was approximately US$ 4, concluding that additional net benefits could be achieved from applying more pesticides. The figure derived in Headley’s analysis has been widely cited and dominated the debate in the following decades. The productivity effects of pesticides were overestimated as neither the level of pests nor the effect of other damage control factors (e.g. agronomic practices) were attributed for.

Lichtenberg and Zilberman (1986) were among the first to point out the methodological problems when a standard production function framework is applied to pesticides. They provided a theoretical explanation why production function specifications, which ignore the damage reduction characteristics of pesticides and treat them as directly yield increasing inputs, can overestimate marginal pesticide productivity. The misspecification of the production relationships, the omission of pest population levels and other environmental factors and the use of pesticide expenditure as a variable instead of the total costs of abatement in previous analyses attribute productivity effects to pesticides which in reality are caused by other factors. As a remedy, Lichtenberg and Zilberman (1986) suggest to modify the conventional (logarithmic) specification of the C-D production function:

$$\ln Q = \alpha + \beta \ln Z + \gamma \ln X$$

with “Z” as productive inputs and “X” being pesticide inputs, by incorporating an abatement function: G(X) as follows:

G(X) with a distribution form of Pareto: $1 - K^{\lambda} X^{-\lambda}$

G(X) with a distribution form of Exponential: $1 - e^{-\lambda x}$

G(X) with a distribution form of Logistic: $[1 + \exp\{\mu - \sigma X\}]^{-1}$

G(X) with a distribution form of Weibull: $1\text{-}\exp\{X^{c}\}$

showing the proportion of the destructive capacity of the damaging agent eliminated by the application of a level of control agent “X”, i.e. pesticides. They show that the marginal product (marginal effectiveness) of the damage control agent in the abatement function specification G(X) declines faster than the marginal product of pesticides in the C-D function (1/X) with a constant elasticity.

Empirical studies applying the Lichtenberg and Zilberman (LZ) framework confirmed their hypothesis. For example, Babcock *et al.*, (1992) compared the marginal product derived from a conventional C-D function with a damage control specification, using data of North Carolina apple producers and found that the C-D results exceeded the damage function estimate by a factor of almost 10. Including state variables in their production process model, Blackwell and Pagoulatos (1992) suggest that ignoring natural abatement factors may overestimate the marginal productivity of pesticides. Chambers and Lichtenberg (1994) applied a dual representation of the LZ damage control specification to an aggregate US agriculture data set. They concluded that the aggregate pest damage in US agriculture was lower than previous estimates suggested. Their model also hints at the important distinction between pesticides as single damage control agents and total damage abatement. The long run price elasticity of pesticides was found to be in the order of -1.5, while the elasticity of abatement subject to the prices of all other input factors was found to be consistently less than -0.1 suggesting that the contribution of pesticides to the economic outcome of pest control is overestimated.

On the other hand, it was also shown that the choice of the functional form influences the conclusion as regards pesticide productivity. For example, Carrasco-Tauber and Moffit (1992) used the Lichtenberg/Zilberman (LZ) framework to analyse 1987 cross-sectional data. They compared the conventional C-D function with three different specifications of the abatement function (Weibull, logistic and exponential). The exponential form in the damage control specification showed a marginal productivity of pesticides of less than unity suggesting pesticide overuse, while all other functional specifications showed results similar to those found by Headley (1968). Although the exponential form is commonly used in pesticide kill functions (e.g. Regev *et al.,* 1976) there is no theoretical basis for choosing one functional form instead of the other.

Furthermore, the restrictions of an output-oriented damage function were demonstrated by Carpentier and Waever (1997). They proposed instead a more general input damage abatement specification which was recently applied to panel data of Dutch arable farms by Lansink and Carpentier (2001). However, the empirical evidence of different productive impacts of pesticides was found to be weak. Taking these findings into account lends support to the hypothesis that the original LZ-specification of the damage abatement function may be the appropriate methodology to be used in estimating pesticide productivity. Furthermore, results from applying the damage abatement function not only confirm the results of farm level economic studies but also those of numerous casual observations of pest management specialists (e.g. Kenmore 1996) that insecticides in rice are overused.

3.2.2 Data Use

A sample of 241 farmers as mentioned in chapter 2 was used for the analysis. Data were collected at two points of time: February 2000 for the cropping year 1999/2000 and for the following cropping cycle in February 2001.

3.2.3 Econometric specification of the damage control functions

The typical production function form used to estimate productivity of external inputs is the Cobb-Douglas function. In the incorporation of a damage abatement function for the estimation of pesticide productivity alternative econometric specifications exist. In this analysis the exponential, the logistic and the Weibull functions were used. In mathematical terms the following specifications were utilized:

(1) Cobb-Douglas: $\ln Y = \ln A + \beta_i \ln Z_i + \gamma \ln X_i$

(2) Exponential: $\ln Y = \ln A + \beta_i \ln Z_i + \ln[1-\exp(-\lambda X)]$

(3) Logistic: $\ln Y = \ln A + \beta_i \ln Z_i + \ln[1+\exp(\mu-\sigma X)]^{-1}$

(4) Weibull: $\ln Y = \ln A + \beta_i \ln Z_i + \ln[1-\exp(-\lambda X^C)]$

where:

Y is the value of output in Baht per rai.

A is the constant value.

Z_i are the production inputs such as seed, fertilizer, and labor.

X_i are the damage control agents i.e. pesticides.

The marginal productivity can be estimated using the following formula.

For the input Z_i, the marginal value product of Z_i is

$$MVP(Z_i) = \frac{\partial Y}{\partial Z_i} = \beta_i \frac{Y}{Z_i} \tag{3.1}$$

For the input X_i, the marginal value product of X_i is

$$MVP(X_i) = \frac{\partial Y}{\partial X_i} = \frac{Y}{D(X)} * \frac{\partial D(X)}{\partial X_i} \tag{3.2}$$

where; D(X) is the specification form of damage control agent i.e. exponential, logistic or Weibull.

3.3 Results

Three models were used to estimate production coefficients for the input variables of rice production. The first model is based on data from all five provinces for the cropping year 1999/2000 (Table 3.1) while the second one represents cropping year 2000/2001 (Table 3.2). Finally, a separate production function was estimated for the Central Plains of Thailand (Table 3.3) because it is there where rice cultivation is most intensive. Input variables include inputs such as fertilizer, seeds, labour, and pesticides, generally believed to be important determinants of rice output.

The equations were selected based on the goodness of fit and the significance of the regression coefficients and the general significance of the regression equation. The coefficient of multiple determination (R^2) of all models range from 0.19 to 0.50 implying that there are also other factors that explain the value of rice output. However, the important quantifiable factors were included. They generally showed the expected signs and the coefficients were statistically significant. (see Tables 3.1, 3.2 and 3.3).

In terms of the individual variables, *fertilizer* showed the expected positive effect on rice production in all equations. However, this only holds for urea but not for the phosphorous fertilizer 16-20-0. Based on anecdotal evidence improper use of 16-20-0 is widely found in the Central Plains of Thailand where farmers often apply excessive amounts of 16-20-0 in the early period of rice cultivation.

For *seeds*, the positive impact of seed on the value of rice production occurred in all models, indicating that with an overview picture of Thailand, an increase in amount of seed, the increase in value of rice products will be obtained.

Labour showed a positive effect on the value of rice production occurred in all models. However, when considering the labour use in central region of Thailand, the negative impact of labour on rice production occurred. This is because there is a high labour use in this area due to an over-application of several inputs such as pesticides and fertilizers (as already mentioned above) (Table 3.1, 3.2 and 3.3).

Pesticides had a positive impact on the value of rice production in all three models. However, the derived production elasticity is low, i.e. the supply response to additional amounts of pesticides is small. In the conventional Cobb-Douglas function form, the coefficient of pesticides shows that a 1 % increase in pesticide expenditure in rice fields will increase rice output by only 0.019 % and 0.024 % for rice production in Thailand for the cropping season 1999/2000 and 2000/2001 respectively (Table 3.2 and 3.2). It is must be mentioned that in the Cobb Douglas production function for the Central Plains (Table 3.3) insecticides and herbicides were defined as separate variables but only the latter was statistically significant.

Table 3.1: Production coefficients of Cobb-Douglas and Damage function specification of rice cultivation in Thailand, the cropping year 1999/2000.

Independent Variables	Cobb-Douglas	Damage function specification		
		Exponential	Logistic	Weibull
Constant	6.3054	6.1828	6.0089	6.7421
Nitrogen	0.0395	0.0467	0.0557	0.0406
	(1.90)*	(2.24)**	(2.75)***	(1.96)*
Phosphorus	0.0540	0.0541	0.0513	0.0539
	(7.12)***	(6.94)***	(6.70)***	(7.09)***
Seed	0.2123	0.2454	0.2685	0.2172
	(5.15)***	(6.31)***	(7.36)***	(5.32)***
Labor	0.0188	0.02126	0.0234	0.0192
	(1.84)*	(2.07)**	(2.28)**	(1.88)*
Pesticide	0.0199			
	(2.76)***			
Lambda (λ)		232.5093		
		(4.00)***		
Sigma (σ)			-0.0931	
			(-11.42)***	
μ			-457.027	
			(-72.48)***	
C				0.0319
				(2.56)**
N	241	241	241	241
R-square	0.4971	0.4865	0.4807	0.4960
F-statistic	46.45***	44.53***	36.10***	46.25***

Note: the value in bracket are t-value

* , ** and ***: statistical significant at 90%, 95% and 99%

Table 3.2: Production coefficient of Cobb-Douglas and Damage function specification of rice cultivation in Thailand, the cropping year 2000/2001.

Independent Variables	Cobb-Douglas	Damage function specification		
		Exponential	Logistic	Weibull
Constant	6.6657	6.5582	7.2162	7.1079
Nitrogen	0.0555	0.0684	0.0432	0.0571
	(1.71)*	(2.11)**	(1.32)	(1.76)*
Phosphorus	0.0450	0.0477	0.0436	0.0498
	(4.13)***	(3.86)***	(3.65)***	(4.09)***
Seed	0.1124	0.1433	0.0664	0.1165
	(2.48)**	(3.29)***	(1.35)	(2.59)***
Labor	0.0244	0.0260	0.0212	0.0246
	(1.99)**	(2.11)**	(1.72)*	(2.01)**
Pesticide	0.0240			
	(2.64)***			
Lambda (λ)		218.9042		
		(3.48)***		
Sigma (σ)			0.1032	
			(1.50)	
μ			-0.8216	
			(-2.14)**	
C				0.0391
				(2.48)**
N	241	241	241	241
R-square	0.2726	0.2581	0.2890	0.2715
F-statistic	17.62***	16.35***	15.85***	17.51***

Note: the value in bracket are t-value

* , ** and ***: statistical significant at 90%, 95% and 99%

Table 3.3: Production coefficient of Cobb-Douglas and Damage control function specification of rice cultivation in Central Plains of Thailand, the cropping year 1999/2000.

Independent Variables	Cobb-Douglas	Damage control function specification		
		Exponential	Logistic	Weibull
Constant	8.4953	8.9803	9.0565	9.3131
Urea (46-0-0)	0.0702	0.1044	0.0901	0.0803
	(1.28)	(1.95)*	(1.66)	(1.44)
Fertilizer	-0.1817	-0.1679	-0.1695	-0.1797
16-20-0	(-3.68)***	(-3.43)***	(-3.47)***	(-3.62)***
Labor	-0.0836	-0.0955	-0.0918	-0.0695
	(-1.79)*	(-2.07)**	(-2.01)**	(-1.52)
Herbicide	0.1075			
	(2.25)**			
Insecticide	0.0391			
	(1.04)			
Herbicide		0.0709	0.0556	0.2186
(σ_1)		(4.72)***	(2.15)**	(0.58)
Insecticide		0.1534		0.0947
(σ_2)		(2.10)**		(0.67)
μ			0.1369	
			(0.23)	
N	111	111	111	111
R-square	0.1927	0.2097	0.2223	0.1872
F-statistic	5.01***	5.67***	6.00***	4.84***

Note: the value in bracket are t-value

* , ** and ***: statistical significant at 90%, 95% and 99%

The derived *marginal value product* (*MVP*) *of pesticides* was found to be greater than unity in the Cobb-Douglas function, whereas those derived from the damage control function specifications show lower values. In the first place this confirms the hypothesis of Lichtenberg and Zilberman (1986) of an overestimation of pesticide productivity. However, as also found in previous studies (e.g. Carrasco-Tauber and Moffit 1992), results depend on the damage function specification. For example, the MVP derived from the logistic function is similar to those of the Cobb Douglas specification (Table 3.4).

Based on the statistical quality of the regression results the exponential model was used as basis for comparison (Table 3.3 and 3.6). The MVP from the exponential model in both cropping season of rice cultivation in Thailand and Central plain range from 0.000 to 0.002, whereas the MVP of the Cobb-Douglas ranges from 1.49 to 3.24 (Tables 3.4 and 3.5).

In general, the results confirm that the treatment of pesticides in the traditional specification of a production function leads to overestimation of their productivity effects. Likewise this may imply a slight underestimation of the productivity of the standard inputs (e.g. labour, fertilizer).

Table 3.4: Marginal Value Product of Pesticides and other farm inputs of rice cultivation in Thailand , cropping year 1999/2000.

Inputs	Cobb-Douglas	Damage function specification		
		Exponential	Logistic	Weibull
Nitrogen (Baht/rai)	1.7192	2.0959	1.7779	2.4265
Phosphorus (Baht/rai)	20.0323	20.6426	20.1046	19.0697
Seed (Baht/rai)	4.9015	5.8278	5.0327	6.2008
Labor (Baht/rai)	0.1507	0.1757	0.1545	0.1878
Pesticide (Baht/rai)	5.2409	0.0000	4.7239	0.0000

Table 3.5: Marginal Value Product of Pesticides and other farm inputs of rice cultivation in Thailand, cropping year 2000/2001.

Inputs	Cobb-Douglas	Exponential damage control function
Nitrogen (Baht/rai)	2.1312	2.6819
Phosphorus (Baht/rai)	9.5836	9.3680
Seed (Baht/rai)	3.2583	4.2449
Labor (Baht/rai)	0.1929	0.2102
Pesticide (Baht/rai)	4.5359	0.0000

Table 3.6: Marginal Value Product of Pesticides and other farm inputs of rice cultivation in central region of Thailand, cropping year 1999/2000.

Inputs	Cobb-Douglas	Exponential damage control function
Urea	1.3544	2.0828
Fertilizer 16-20-0	-2.7892	-2.6650
Labor	-0.9192	-1.0858
Herbicide	5.0491	2.1392
Insecticide	1.4996	0.0021

3.4 Conclusions and Recommendations

Unlike direct productive inputs e.g. land, labour and capital, pesticides are damage control inputs and therefore do not increase the output directly. Their contribution depends on their ability to increase the share of potential output that farmers realize by reducing damage from pests (Lichtenberg and Zilberman, 1986). Thus, the functional specifications for damage control agents are different from the typical production function like Cobb-Douglas. The results found in this study confirm that the types of production function specifications used most commonly (i.e. Cobb-Douglas) to estimate factor productivity overestimate the productivity of pesticide inputs. Hence, it is recommended that a more sophisticated approach to assess the productivity of damage abatement in production like Exponential, Logistic or Weibull functions should be incorporated into the economic work for future planning on the damage control agents like pesticides.

Results of this study may be useful for decision makers that are challenged with the reform of crop protection policy in Thailand towards reducing the dependence on chemical pesticides. In designing policy incentives to increase the productivity of rice production, policy makers should avoid distortions in favour of pesticide use, not only because of their demonstrated and assumed negative externalities (e.g. Jungbluth 1996) but also because of their lower than expected productivity effects. The results of this study also underline that in determining the need for biotechnology of crop protection in rice (e.g. Bt rice) it is important to first establish a realistic reference system (Zadoks and Waibel 2000) if wrong expectations as regards the benefits of such technologies are to be avoided.

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4 Farm-Level Economic Analysis of Farmer Field Schools in Integrated Pest Management[2]

4.1 Introduction

Before up-scaling FFS to a larger number of farmers the question of economic impact and cost-effectiveness arises. For Asian conditions the costs of a Field School were estimated to be in the order of US$ 2000 per season (Fleischer *et al.,* 2002) excluding the cost of the trainer. Therefore, some researchers have questioned the cost-effectiveness of the FFS model (Heong *et al*., 1998). Furthermore, its fiscal sustainability was questioned especially because the assumption that FFS graduates would become trainers in further field schools – which in theory would speed up its diffusion - was queried based on available evidence from the Philippines and from Indonesia (Quizon *et al*., 2001). In order to assess the impact of FFS, three issues must be dealt with:

1. The effectiveness of the training method in terms of participation and improving participant knowledge.

2. The degree of practice change due to the training and effect on income on the short run.

3. The long-term and diffusion effects of FFS.

The first question stems from the training method itself. The training curriculum demands that participants follow a complete crop cycle in order to be able to internalize the complex principles that underpin ecological processes of the development of pests and natural enemies. Therefore, irregular or partial participation in the season-long training could weaken the understanding of participants anticipated by the proponents of the FFS approach. An analysis of this question was carried out elsewhere (Praneetvatakul and Waibel, 2002). The second question is related to practice change that is expected to result from FFS training. Practice change is a pre-condition to realize short-term economic benefits of the FFS model. The underlying assumption is that distortions in agricultural policies such as input subsidies have made farmers use inputs inefficiently. Existing evidence from the rice research literature suggest, for example, that pesticide inputs could be reduced without suffering

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2 Part of the paper has been presented in a poster session at the 25th International Conference of Agricultural Economists, 16-22 August 2003, Durban, South Africa. The paper was published in: *Thailand Journal of Agricultural Economics*, (2004) Vol 23, No.2 , p. 49 – 66.

yield losses (e.g. Rola and Pingali, 1993). It was also found that rice yields can even be increased with less external inputs after modifying agronomic practices in a system called 'sustainable rice intensification' (e.g. Uphoff *et al.*, 2002). Both examples indicate that improving farmer's crop management and decision-making abilities can increase their profits and reduce potential negative externalities from chemical inputs on human health and the environment. The third question requires long term observations which for the time being are not available. Therefore, this paper concentrates on the second question. The main objective is to investigate the short-term impact of FFS on the profitability of the rice crop using a profit function approach.

4.2 Theoretical Framework and Methodology

4.2.1 Farm-level Impact Analysis

Impact analysis at the farm level investigates whether FFS participants have achieved a more efficient farm input use resulting in higher farm profits. Based on Feder and Quizon (1998), the following simplified model of a rice farm that produces a single output (Y_1) using multiple variable inputs ($X_1, X_2, ..., X_m$), including chemical pesticides (Xp) can be conceptualized. The household maximizes profits (Π) from considering the prices of farm outputs and variable inputs, but subject to constraints from fixed factors. These fixed factors include fixed inputs such as available land (L), the farmer’s general level of pest management knowledge (K), and other factors (Z). The variable K is the main target of IPM diffusion efforts.

The farm household’s maximized profits can be written as a primal profit function:

$$\Pi = \pi(\bar{P}x;\ \bar{P}y; L, K, Z), \tag{4.1}$$

where: $\bar{P}y$ refers to the vector of output ($\bar{Y}$) prices, $\bar{P}x$ to the vector of variable input ($\bar{X}$) prices, and with output supply and input demand equations as follow,

$$Y = f(\bar{P}x;\ \bar{P}y; L, K, Z) \tag{4.2}$$

$$X = g(\bar{P}x;\ \bar{P}y; L, K, Z). \tag{4.3}$$

For IPM and its dissemination, the desired impact on profits comes from raising farmers’ improved ecosystems understanding to be labelled as knowledge (K). A rise in K eventually leads to a change in the input mix and other agronomic practices used, and in particular, to a lower use of pesticides. Supposedly, higher profits follow from a decline in pesticide use and a reallocation of other inputs. Eventually higher outputs owing to more effective plant protection and improved technical and allocative efficiency may be observed. From equations (2) and (3), the premises are that:

$$\partial Xp/\partial K < 0 \text{ and } \partial Y/\partial K > 0. \qquad \text{(i)}$$

Ceteris paribus, FFS participants are expected to have greater awareness and knowledge (K_a) than non-participants (K_{na}). This suggests that:

$$K_a > K_{na}, \text{ and therefore:} \qquad \text{(ii)}$$

$$Y_a > \bar{Y}_{na}, \quad \bar{X}_a < \bar{X}_{na,} \text{ and } \Pi_a > \Pi_{na}, \qquad \text{(iii)}$$

Where the subscript *a* refers to farmers who participated in field schools, and the subscript *na* to those who did not participate, i.e. the farmers of the control village. The outcomes for farmers who did not participate in the training but who live in the village where the FFS took place would fall within these two groups although it can be argued that these would be nearer to non-participants given the highly demanding training approach. On the other hand, such effects cannot be excluded as several previous studies on extension have found (e.g. Foster and Rosenzweig 1995, Feder and Slade 1984) that farmers often get information from relatives and neighbours. Statement (iii) describes some of the desired consequences of IPM efforts, i.e., to raise farm yields, lower pesticide use and thereby, raise farm profits.

4.2.2 Data Use

The data from the first two surveys described in chapter 2 are used and include a sample of 224 farmers.

4.3 Results

4.3.1 Farm Level Benefits of FFS

As a first step group means of relevant parameters were compared by using t-test for the before-and-after comparison and using F-test for the within-group comparison. The simultaneous group comparisons allow separating the effects of environmental conditions from those of the training. While in the before-training-situation a non-significant difference indicates similar base conditions the opposite result after training indicates that training had some short term impact. This must be confirmed by a significant difference between before and after for FFS participants and an opposite result for non-participants. Results show that farmers who participated in the training have significantly lower pesticide costs as compared to the non-participants and the control group (Table 4.1). This is also true for herbicides, snail poisons, and insecticides (Table 4.2).

Table 4.1: Comparison of average pesticide costs by farmer groups in Baht/rai.

Parameters	Before training	After training	t-value
- FFS farmers	153.47	83.03	4.201***
- Non-FFS farmers	175.19	159.10	0.987^{ns}
- Control group	143.88	124.56	1.508^{ns}
F-test	0.349^{ns}	5.557***	

Note: *, ** and *** significant at 90%; 95%; and 99%; ns = non-significant difference

The situation is different for fungicides where a significant difference already existed before the FFS. In the subsequent season, non-participants in the same village increased fungicide significantly while FFS farmers lowered the use of these inputs but the difference is not significant (Table 4.2).

Table 4.2: Comparison of average pesticide costs by type and farmer groups in Baht/rai.

	Parameters	Before training	After training	t-value
Herbicide	- FFS farmers	31.16	25.10	2.471**
	- Non-FFS farmers	40.42	35.46	0.952 ns
	- Control group	40.58	34.79	1.199 ns
	F-test	1.111 ns	2.062 ns	
Snail poisons	- FFS farmers	41.26	16.86	2.142**
	- Non-FFS farmers	33.78	35.35	-0.215 ns
	- Control group	22.52	26.93	-0.976 ns
	F-test	1.023 ns	4.766***	
Insecticide	- FFS farmers	41.19	17.26	3.451***
	- Non-FFS farmers	50.27	49.79	0.056 ns
	- Control group	31.68	28.41	0.594 ns
	F-test	0.784 ns	7.108***	
Fungicide	- FFS farmers	17.75	14.14	0.945 ns
	- Non-FFS farmers	18.02	27.91	-2.007**
	- Control group	15.03	20.56	-0.945 ns
	F-test	3.756**	2.807*	

Note: *, ** and *** significant at 90%; 95%; and 99%; ns = non-significant difference

Rice yields were not significantly different among the three groups of farmers, neither before nor after the training season. However, comparing before and after training, rice yields were higher in season after the training for all three groups of farmers because the crop year 2000/2001 had more favourable production conditions (Table 4.3).

Table 4.3: Comparison of average yield by farmer groups in kg/rai.

Parameters	Before training	After training	t-value
- FFS farmers	559.44	592.98	1.857*
- Non-FFS farmers	564.76	604.13	1.827**
- Control group	509.05	558.05	2.567***
F-test	1.135 ns	0.654ns	

Note: *, ** and *** significant at 90%; 95%; and 99%; ns = non-significant difference

While a comparison of group means can provide first indications for the farm level impact of FFS, these results need to be verified by an analysis that is able to capture causality. Therefore in the next chapter a profit function procedure is applied.

4.3.2 Profit Function

Based on the conceptual outline provided above and the data collected from five Farmer Field School projects, a primal profit function was derived according to equation (1). The output supply function and the input demand function were estimated separately through equation (2) and equation (3) respectively. Parameters for all three functions are shown in table 4.4.

Table 4.4: Profit, Production and Input Demand Functions of rice from FFS projects.

Function/ Parameter	(1) Profit Function (Pr)		(2) Output supply function (Y)		(3) Input Demand Function (X)	
	coefficient	t-value	coefficient	t-value	coefficient	t-value
Intercept	4.041	5.737^{***}	4.661	12.746^{***}	0.181	0.207^{ns}
lnP_y	1.258	3.047^{***}	-0.0889	-0.449^{ns}	0.779	1.639^{*}
lnP_x	-0.768	-0.681^{***}	-0.501	-5.016^{***}	-0.216	-0.902^{ns}
FFS	0.318	1.930^{*}	0.164	2.035^{**}	-0.383	-1.982^{**}
LnL	0.099	0.087^{ns}				
lnC_x			0.237	8.809^{***}	0.685	10.613^{***}
adj. R^2		0.182		0.556		0.538
F-statistics		6.287^{***}		38.155^{***}		35.560^{***}
N		118		127		127

Where; lnPr= profit measured as gross revenue above variable cash cost (Baht/rai), lnY= quantity of rice (kg/rai), lnX = quantity of snail poisons (c.c./rai), lnP_y= price of rice (Baht/kg), lnP_x= price of snail poison (Baht/c.c.),FFS= farmer participating in the Farmer Field School (1=yes, 0=no), lnL= rice area (rai), lnC_x= total costs of pesticide (Baht/rai),

*, ** and *** statistical significance at 90%, 95% and 99% respectively; ns = non-significance

Results of the profit function show a low R^2 but with the exception of "rice area" all coefficients are significant and have the expected sign. Note that the coefficient "P_x" has a negative sign, i.e. farmers respond to the price of snail poison used to control the "golden snail", perceived to be a major pest of rice. FFS training can be an effective means in reducing uneconomical pesticides use and slightly increasing profits, i.e. participation in FFS will increase the gross margin of rice by 0.32%. However the knowledge coefficient (Dummy variable for FFS) was found to be significant at the 90% level only.

The statistical quality of the output supply function is better than that of the profit function. Productivity is positively affected by FFS participation for which the coefficient is significant, i.e. farmers participating in FFS tend to have higher yields. Total costs of pesticides shows a positive effect on rice yield and the coefficient is significant. Such result needs to be treated with care in view of the difficulty of interpreting damage abatement variables in output supply functions. The coefficient for the rice price has a negative sign but is non-significant. In principle, this result violates the basic assumption of profit maximizing behaviour. On the other hand, the negative sign for the price of snail poison suggests that farmers take input prices into account when making damage control decisions.

The input demand function refers to snail poison as the dependent variable. Due to the perceived problem with snails, extremely hazardous chemicals are used for their control. The coefficients of the input demand function all show the expected sign indicating that farmers react to input and output price changes. FFS participation tends to reduce the use of snail poison as the knowledge coefficient was found to be significant. On the other hand, farmers who spend more on total pesticides tend to use more snail poison.

4.4 Summary and Conclusions

As a knowledge-intensive new technology, Farmer Field Schools in IPM provide a challenging case for economists to carry out impact assessment and to provide further guidance for policy makers and agricultural administrators. Such studies are urgently needed for designing effective extension strategies in developing countries. Although widely praised, so far very little quantitative evidence exists as regards the benefits of FFS and their effect on farmers' income. A major constraint to conduct such analysis has been the unavailability of data.

In the case study from Thailand presented here, we were able to collect some of the necessary data following a social science experimental design. The analysis presents a first attempt to explore different angles necessary for carrying out an economic analysis of FFS. In this paper, we limit the analysis to the income effects on farm level. By performing multiple group comparisons we were able to show that FFS can be an effective means to reduce uneconomical pesticide use of rice farmers. However, the results are less clear as regards the effect of FFS on rice yields.

The primal profit, output supply and input demand functions computed from the data are meant to facilitate a test for the existence of a causal link between FFS and crop management performance. The different functional specifications assumed to represent possible effects from FFS training were found to be largely consistent with assumed economic behaviour. Hence, results are valid for testing the hypothesis that raising farmers' ecosystems understanding through Farmer Field Schools can increase productivity of rice growing.

Results confirmed the widespread observation that FFS participants reduced their pesticide inputs. This is perhaps not surprising as the training puts emphasis on alternative methods of pest management. However, it also appears that both farm profits and yield can be increased by increasing farmer's knowledge and by enhancing their understanding of ecosystems as emphasized by FFS. Nonetheless, statistical evidence for these observations is weak. It appears that a larger number of field schools are necessary than the one available to us. A further refinement of the analysis could be achieved if the sample is redesigned after taking into account participation rate and training performance (Praneetvatakul and Waibel, 2002). Also, no conclusion can be drawn as regards the knowledge retention effects. Whether or not farmers go back to their old practices after some time is analyzed in the following chapter of this book, where the data from a third survey are used to estimate a 3 period DD model.

With additional analysis further questions as specified at the outset can be tackled. For example, the question of implementing FFS programs on a large scale needs to be investigated in connection with the possibilities of quality control and fiscal sustainability. Both factors require studying appropriate institutional mechanisms. Secondly, in order to assure cost-effectiveness the questions of targeting FFS appears to be important. Given the impact observed in this study, targets for FFS in Asia are those areas where pesticide are overused and crops where pest control costs are high. Clearly, here FFS can help to make pest control more economical and reduce negative externalities. However, FFS also needs to be compared with other instruments to achieve such a goal, e.g. raising pesticide prices through levies or taxes. In many African countries, where FFS is starting to become popular is different: Here their role as a component of a strategy for sustainable intensification needs to be studied in agricultural systems where the use of external inputs is still low.

Finally, it is recognized that there are further methodological issues in impact assessment of FFS that refer to some basic estimation, assessment and evaluation problems. The major ones shall be listed as follows:

- the self-selection issues related to IPM/FFS participation,
- possible positive spillover effects of FFS,
- the non-market benefits attributable to lower levels of pesticide use,

the utility that may be attributable to farmer empowerment effected through gaining knowledge and confidence from FFS, and their contribution to building local institutional capacity.

In conclusion, while some light could be shed on impact from FFS in IPM several questions remain whose answer depends on further data and on methodological advancements of the analysis.

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5 A Socio-Economic Analysis of Farmer's Drop-out from Training Programmes in Integrated Pest Management[3]

5.1 Introduction

The main factor determining the cost-effectiveness of the training and benefits obtained from the Farmer Field School is farmer participation. One of the aspects of FFS programmes is that they often are believed to be costly and time-consuming (Heong *et al*., 1998; Quizon *et al*., 2001). During the cropping season, farmers are expected to attend weekly half- to whole-day training sessions in the field, guided by a trainer/facilitator. Since the objective of training is to generate an understanding of principles rather than transferring simple rules for decision making, farmer participation is a pre-condition for success. Hence, if participants drop-out during the course, the objectives of the training are not being reached and scarce public funds are wasted. On the other hand, if agricultural administrators want to devise effective means to reduce the rate of drop-out, it is important to gain a better understanding of the factors which cause farmers to attend training irregularly or even discontinue the course. Furthermore, knowledge about farmer's demand for training and their participation is crucial for the design of up-scaling strategies for knowledge-intensive agricultural technologies.

Recently, economic researchers from the World Bank have raised doubts about the sustainability of the FFS approach (Quizon *et al*., 2001). It is therefore important to assess the economic and other non-market benefits which can be derived from participating in farmer field schools using sound economic methodology. Unfortunately, previous studies do not provide clear evidence of costs and benefits. This chapter aims to analyse factors affecting drop-out of farmers participating in farmer field schools in Thailand. It describes a study using a well-planned experimental design to identify drop-out determinants. The study aims to contribute in finding ways and means to reduce the rate of drop-out through improving the design of Farmer Field School Programmes.

[3] Paper presented at the international workshop on "Participatory Technology Development and Local Knowledge for Sustainable Land Use in Southeast Asia", 6-7 June 2001, Chiang Mai, Thailand

5.2 Theoretical framework and methodology

5.2.1 Analytical Framework

A multinomial logit model is applied to determine the factors that affect drop out from field schools in the study. Three levels of participation were defined, full participation, participation and drop out, based on the number of training sessions attended. The choice to participate or to drop out is expressed as a binary logit model and then extended to the three stage choice for all levels of participation.

The logit model is based on the cumulative logistic probability function and is specified as follows (Pindyck and Rubinfeld, 1991: 258):

$$P_i = F(Z_i) = F(\alpha + \beta X_i) = \frac{1}{1+e^{-Z_i}} = \frac{1}{1+e^{-(\alpha+\beta X_i)}} \tag{5.1}$$

P_i is the probability that an individual will make a certain choice, given X_i, i.e. to participate or drop out from the field school, *Xi* are the independent variables: socio-economic factors that may affect the participation of farmers in the training programme, while *e* represents the base of the natural logarithms.

If we approximate P_i as follows,

$$\hat{P}_i = \frac{r_i}{n_i} \tag{5.2}$$

where, r_i represents the number of times the first alternative is chosen by individuals with a given X_i, (e.g. number of farmers drop-out) and n_i is individuals having given X_i.

We can estimate the logit probability model by the following:

$$\log \frac{\hat{P}_i}{1-\hat{P}_i} = \log \frac{r_i / n_i}{1 - r_i / n_i} = \log \frac{r_i}{n_i - r_i} = \alpha + \beta X_i + \varepsilon_i \tag{5.3}$$

The above equation is linear in the parameters and can be estimated using ordinary least squares or the maximum likelihood procedure.

To extend the binary-choice logit model to three-choice case, we write:

$$\log \frac{P_2}{P_1} = \alpha_{21} + \beta_{21} X \text{ ,} \tag{a}$$

$$\log \frac{P_3}{P_1} = \alpha_{31} + \beta_{31} X \text{ ,} \tag{b}$$

where $P_1+P_2+P_3 = 1$

Such models have been applied in similar studies as related to multi-stage technology adoption or in the analysis of contingent valuation studies with discrete revealed amounts of willingness to pay (Shakya and Flinn, 1985; Nkonya *et al*., 1997).

Participation in FFS and dropout are assumed to depend on the quality of training and farmer characteristics. In this paper two types of FFS implementation were included: the standard procedure with weekly meetings over 16 weeks and a shorter training with only 8 training sessions Of the farm and farmer characteristics prior knowledge on pest and crop management and the pesticide costs are indicators of the potential benefits the farmer can derive from training. Available labour and farm size are linked to the opportunity costs for the farmer to participate in the training sessions. Hence the empirical model in this analysis is as follows:

$$Y = f\,(PC, D, Kn, FS, ML, Ry) \qquad (5.4)$$

Where, choices of dependent variable are:

Y = 0, farmers who dropped out from the field school

Y = 1, farmers who partially participated the course

Y = 2, farmers who completed the course

Independent variables are:

PC = pesticide costs (Baht/rai)

D = dummy variable of length of training (short=0, long=1)

Kn = prior knowledge of farmers on pest and crop management

FS = farm size (rai/household)

ML = full-time agricultural labour per unit of agricultural land

Ry = rice yield (kg/rai)

The estimation of the probability for each choice is as follows.

$$\text{Prob}\,(Y_i = j) = e^{\beta' X_i} / (1 + \Sigma\, e^{\beta' X_i})$$

$$\text{Prob}\,(Y_i = 0) = 1 / (1 + \Sigma\, e^{\beta' X_i})$$

Y_i Choice of dependent variables, i = 0 to j

β' coefficients of independent variables

X_i Mean of independent variables

5.2.2 Data Use

The analysis is based on a sample of 124 farmers from 5 FFS in different provinces in Thailand (see Table 5.1). As explained in chapter 2, the survey took place in February 2000, before the FFS started.

Table 5.1: Location of Field School by Province and number of participants.

Region/Province of FFS	Number of farmers
Chainat	25
Angthong	23
Kampaengpetch	24
Kalasin	36
Udonthani	16
Total	124

5.3 Results

The results of the study include the training participation rate, the socio-economic characteristics of the three groups of farmers, factors affecting the drop-out of farmers and the probability assessment.

5.3.1 Participation Rate

After the completion of the season-long farmer field school (FFS) training, the survey of farmers participating in FFS revealed the degree of participation in the training. Drop out was classified into three categories. Certainly, it is difficult to judge the minimum participation required in order for a farmer to be able to benefit from the training and significantly improve his/her pest management decision-making capability. As shown in Table 5.2, about one fifth of all participants participated in less than 50 percent of total training periods. Given the nature of the FFS, with emphasis on experiential learning and capturing concepts rather than learning facts, missing half the sessions is unlikely to make participants reach the course objective. Hence these were considered drop-outs. This is based on an expert's opinion (the director of the

Institute of Biological Agriculture and Farmer Field Schools in the Department of Agricultural Extension), that farmers attending more than 50 percent of the sessions could catch the most important ideas of the training. The second group labelled as partial drop-outs participated in more than half of the sessions but missed more than two of the meetings. The remaining 41 percent of farmers were defined as full course participants as they abstained from a maximum of two sessions or participated in between 87.5 percent and 100 percent of sessions[4]. Therefore, the proportion of trainees who at least had a fair chance of grasping the concept of ecology-based pest management was over 80 percent. However, such judgements necessarily remains subjective In any case non–attendance increases the unit costs of farmers trained, a figure which raises concern especially among funding agencies (Quizon *et al*., 2001).

Table 5.2: Farmers participation in all farmer field schools studied.

Group of farmers	Participation rate (%)	Number of farmers	Percentage
Cancel and Drop-out	<50	24	19.35
Partial participate	50-87.4	49	39.52
Course completion	87.5-100	51	41.13
Total		124	100.00

5.3.2 Socio-Economic Characteristics

Comparing the three groups of participants (drop-out, partial participation and course completion) shows that they are rather similar in terms of their socio-economic characteristics (Table 5.3). No differences exist in terms of the participants' age and farming experiences. On average, the variable "knowledge of pest and crop management" is the same in all three groups. When considering the gross income from rice and off-and non-farm income there is no significant difference among the three groups (Table 5.3). The farm size is lower in the drop-out group, however the yields per ha are higher as compared to partial completion. Further explanations of the variables are given with the results of the multinomial logit model.

[4] 87.5 percent is calculated as 14 out of the total 16 periods of FFS, based on the idea that farmers are permitted to miss two training periods.

Table 5.3: Descriptive Statistics of socio-economic characteristics of farmers in farmer field schools.

	Drop-out	Partial participate	Course complete	
Age (years)	42.00	43.49	42.55	ns
	12.54	*12.03*	*9.91*	
Experience in farming	23.88	26.96	25.25	ns
(years)	*14.45*	*13.49*	*12.75*	
Gross Return of rice	41,183.50	44,630.26	43,685.06	ns
(Baht/household)	*25,621.07*	*38,755.99*	*34,539.09*	
Off- and Non-farm income	27,379.17	36,627.96	28,052.35	ns
(Baht/household)	*41,640.75*	*42,118.80*	*30,794.27*	
Farm size (rai)	19.11[a]	29.13[b]	20.50[b]	*
	12.99	*24.44*	*12.32*	
Rice yield (kg/rai)	625.24[a]	433.42[b]	543.56[ab]	*
	361.29	*246.81*	*290.09*	
Pesticide costs	1,463.57	1,783.97	1,249.07	ns
(Baht/rai)	*1,686.02*	*3,728.98*	*1,476.01*	
Knowledge of crop and pest	15.71	16.14	16.18	ns
management (score)	*3.06*	*2.87*	*2.96*	

Notes: 1) Standard deviation in italics. 2) Using Duncan's multiple range test means with the same letter are not significantly different at the 5 % level.

5.3.3 Factors Affecting Participation of FFS

Of the variables hypothesized as possible explanations of drop-out and included in the model, only some give statistically significant results. Setting the drop-out group as a base (Y=0), the amount of money farmers spend for pesticides and the length of training are the main factors affecting drop-out. Both variables have the positive sign. The variables "knowledge of pest and crop management", "farm size", "man-land ratio" show the positive sign while rice yield as a measure of productivity and the progressiveness of farmers show a negative sign (Table 5.4). The positive sign of pesticide costs indicated as those farmers who spend more on pesticides may show a higher interest given that the course content is highly focused on pesticide reduction. In terms of the length of training, based on the curriculum of the course in the study area, courses can be classified into two types: the full or long period of 16 weeks and the half or short period of 8 weeks. It was found that the period of training has significantly influenced the drop-out of farmers. The long period with regular weekly training sessions tends to make farmers stay in the training; the short training period, where considerable uncertainty often exists as regards to whether or not the training actually takes place, tends to induce the drop-out of farmers. The knowledge of farmers on pest and crop management before they attended the field school training also influences drop-out. It is found that farmers with better knowledge before the training tend to continue the training whereas farmers who know less initially trend to drop-out. Furthermore, a small man-land ratio (e.g. 0.05 person per rai) tends to increase the probability of drop-out. This indicates that farmers with more area per household member are more likely to face labour shortage, i.e. their opportunity costs of labour are higher compared to the large man-land ratio (e.g. 1 person per rai).

5.3.4 Probability Assessment

An analysis of the probability of farmers participating in the FFS with various scenarios compared to the base situation will allow us to draw some conclusions as regards possible measures to reducing drop-out:

Regular season-long training (16 weeks) conducted on a weekly basis, which is one measure of training quality will reduce the probability of drop-out by 53 percent (Table 5.5).

Selecting the more knowledgeable farmers to attend field schools will reduce the probability of drop-out group by a similar level as training quality (Table 5.5).

The probability of drop-out will decline by 80 percent if farmers with a more favourable man-land ratio (e.g. 1 person/rai) are selected for field schools (Table 5.5).

The probability of drop-out declines by 84 percent for farmer participants with larger farms (defined as larger than 100 rai). To the contrary, for small farmers, the probability of drop-out increases by 39 percent (defined with an area of 5 rai or less) (see Table 5.5). Most likely small farmers are those who are less commercially orientated and who are mostly also part-time farmers.

Finally, the probability of drop out declines by 41 percent for farmers with low yield (assumed at 200 kg/rai) while the probability of drop out increases by 54 percent with farmers who have high yields (assume at 1,000 kg/rai) (Table 5.5). This result is surprising and deserves further investigation. It may however be correlated with farm size whereby larger farms tend to have lower per unit yields.

Table 5.4: Results of marginal effect from multinomial logit model.

Variables	Drop-out (Yi=0)	Partially participated (Yi=1)	Course completion (Yi=2)
Constant	0.3003	-0.2229	-0.7735
Pesticide costs (Baht/rai)	-0.00004 (-2.542)**	0.0001 (2.427)**	-0.00006 (-0.913)
Length of training Short, D=0; Long, D=1	-0.2114 (-3.137)**	0.1499 (1.231)*	0.0615 (0.366)
Knowledge of crop and pest management (score)	-0.0157 (-2.163)**	0.0117 (0.690)	0.0040 (0.172)
Farm size (rai)	-0.0029 (-1.439)*	0.0055 (1.108)*	-0.0025 (-0.344)
Full-time agricultural labour per land ratio	-0.2471 (-1.546)*	0.4311 (1.101)*	-0.1840 (0.325)
Rice yield (kg/rai)	0.0002 (2.455)**	-0.0007 (-2.803)**	0.0005 (1.418)*
Number of observations		124	
Log likelihood		-115.22	

Note: Data in the table are coefficient of partial derivatives of probabilities with respect to the vector of characteristics.Data in parentheses are t-values.

Table 5.5: Probability of farmers participated in Farmer field school if situations change.

Scenario	Drop-out	Partial participation	Course completion	Total
Base situation	0.153	0.400	0.448	1.00
Long length of training (D=1)	0.072	0.466	0.462	1.00
High knowledge of pest management (score=23)	0.072	0.470	0.458	1.00
High ratio of agricultural labour per unit of land (ratio=1)	0.031	0.725	0.244	1.00
Low ratio of agricultural labour per unit of land (ratio=0.05)	0.191	0.339	0.470	1.00
Large farm size (100 rai)	0.024	0.777	0.199	1.00
Small farm size (5 rai)	0.213	0.302	0.485	1.00
Low rice yield (200 kg/rai)	0.090	0.629	0.281	1.00
High rice yield (1,000 kg/rai)	0.236	0.137	0.627	1.00

5.4 Conclusions

As shown by this study, pesticide costs and quality of training as measured by the number of weeks and the regularity by which the training is being conducted are the main factors which stimulate farmers to stay on the training course. This allows two somewhat preliminary conclusions. First, given the high costs of FFS relative to ordinary agricultural extension activities, this approach may not be economically justifiable as a nationwide programme. It is more likely to yield high benefits in areas of pesticide overuse. It may also be successful with farmers who practice intensive methods of farming or those who so far have ignored economic considerations in the application of pesticides. Second, a high quality of training is a pre-condition for FFS to be effective. This means FFS cannot be a cheap affair. It needs to be well equipped and trainers need to be given sufficient incentives and support.

Another interesting issue arises from the observation that farmers with better knowledge before the training also tend to be less likely to drop out. It indicates that FFS requires some minimum level of knowledge for farmers to be able to benefit. Hence, the question must be asked whether such training will widen the gap between knowledgeable and less knowledgeable farmers. Also one can ask whether the FFS requires something like a "pre-school" to be able to live up to its full potential.

Finally, on the issue of opportunity cost of labour, it shows that there are also costs of training on part of the farmer. The true costs of FFS exceed those indicated in the budgetary statements of government and international donor agencies. This corresponds with the findings of Fleischer *et al.* (2002) in a study conducted in Egypt.

5.5 Recommendations

A more precise specification of the target group of FFS training is likely to create incentives for participation. For example, if farmer field schools are concentrated in some areas, e.g. in areas where farmers have a history of high pesticide use levels the willingness to participate in more training sessions is likely to be higher than now.

There is a need to better maintain quality control of the training by providing sufficient budget and other incentives for the trainers to perform the FFS. This must include the regular monitoring of the training success of FFS.

Develop and implement complementary measures to increase demand for FFS-type of training by removing hidden pesticide subsidies through crop protection policy reform.

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6 Impact Assessment of Farmer Field Schools using A Multi-Period Panel Data Model[5]

6.1 Introduction

Projects on farmer training in Integrated Pest Management (IPM) in developing countries using the Farmer Field School (FFS) approach are widely implemented by donor organizations including for example the World Bank. This is in spite of criticism that such projects are fiscally unsustainable (Quizon et al, 2001) and are not always effective in changing pest management practices or in improving farmer performance (Feder et al, 2003) and have only limited diffusion effects (Rola et al, 2002, Feder et al, 2004). On the other hand it was shown that FFS could improve farmer knowledge in pest identification and improve their ecosystems understanding (Godtland et al, 2004, van den Berg, 2004, Tripp et al, 2005). A recent review of the impacts of FFS as documented in the literature and using a FAO database challenged the conclusions that FFS impacts are ambiguous (van den Berg and Jiggins 2006). The authors also pointed out several problems with past impact assessment of FFS in IPM.

One of the limitations of past impact analyses of Farmer Field School projects is that in most cases data were being used that did not allow the definition of good counterfactual scenarios because no control area was available or only insufficient baseline data existed. Also comparisons were often based on only two observation points before and after the training. In addition, most of these studies concentrated on simple performance parameters like knowledge, pesticide use and yield but did not include for example impact on the environment. In this paper we again use the panel data set introduced in chapter two. As explained the data were collected over a period of four years covering up to 10 rice-growing seasons from three groups of farmers. The analysis presented in this chapter is an advancement of an earlier study that looked at the short-term impact of FFS in Thailand (Praneetvatakul and Waibel 2003).

[5] An earlier version of the Paper was presented at the 26th Conference of International Association of Agricultural Economist (IAAE), Brisbane, Australia, 12-18 August 2006. The Paper is to be published in the Journal of Developing Areas in 2007.

6.2 Data and impact indicators

Data as mentioned in chapter 2 were used for the analysis. To assess impact of FFS we defined several impact indicators. First, we measured farmers' knowledge of rice and pest management. A score was constructed from a set of knowledge questions developed in cooperation with national IPM experts. Second, total rice yields per farm including sales and home consumption were based on farmers' estimates and divided by the respective area planted to rice. Third, the amount of cash spent on pesticides including insecticides, molluscisides (chemicals used to kill snails), fungicides and herbicides was calculated in $ per ha. Fourth, the gross margin of rice production in $ per ha, measured as total revenue above total variable costs excluding the value of family labour. Fifth, as a measure of net farm benefit we deducted health costs from chemical pesticide use from the gross margin. Health costs were accounted for by using a ratio of pesticide costs to health costs of 1:1 based on the results of the study of Rola and Pingali (1993). Finally, the Environmental Impact Quotient (EIQ) was calculated to quantify the environmental and health impacts of pesticides by means of an index (Kovach, *et al*., 1992). The EIQ index provides a measure of the side effects of pesticides according to crop type, pesticide type, quantity and toxicity to pesticide applicators, toxicity to consumer and toxicity to the ecological environment. The index sums up all pesticides used by a farmer hence a higher EIQ number indicates a higher risk to health and environment.

6.3 The Model

The analysis applies a difference in difference (DD) model (Greene, 2000). DD models can be used to analyse changes in farm performance such as pesticide use, yield and profit. In our analysis we proceeded in two steps. First we investigated linear shifts in performance and second we measured change as a growth process. The linear shift implies a one-off performance change at the observation point relative to the baseline period. The change in the growth rate takes account of the fact that the development process influences performance and thus assumes an exponential path in the rate of change for trained and untrained farmers. Hence the model accounts for the fact that change is taking place even without the FFS training. The linear shift was measured by applying a paired t-test (Anderson *et al*., 2002), to test for the differences between before and after training for FFS, exposed non-FFS and control farmers. For those performance indicators where we find a significant linear shift we proceed with the two and three period growth model. The rationale for this procedure is that we do not expect significant results as we increase the degree of rigor in the testing procedure, i.e. if we do not get a significant difference in the t-test, we cannot expect a significant coefficient in an econometric growth model. Since we have three observation points over time we can apply two alternative models: a two period and a three period panel data model. With the three period model a simultaneous estimation of the time period effects is achieved using a larger sample.

In applying this model we draw upon and expand the procedure developed by Feder *et al*., (2003) used to measuring impact of IPM in Indonesia. Accordingly the change in farmers' performance (e.g. yield) through training can be modelled as an exponential growth process. This is displayed in equation 7.1:

$$Y_1 = Y_0 \cdot \mathrm{e}^{\{\alpha + \beta D_{nffs} + \mu D_{ffs} + \gamma \Delta X + \delta \Delta Z\}} \tag{6.1}$$

where:

Y_1: rice yield after the training,

Y_0: rice yield before the training,

α: coefficient for yield growth before the training,

μ: rate of yield growth of FFS farmers after the training,

β: rate of yield growth rate for the non-FFS farmers after training,

D_{ffs}: dummy variable for FFS farmers, for FFS = 1 and zero = otherwise,

D_{nffs}: dummy variable for non-FFS farmers, for non FFS = 1 and zero = FFS and control,

X: vector of farmer characteristics,

Z: vector of village characteristics,

γ and δ: corresponding coefficients of these vectors,

Δ: the differencing operator between before and after the training,

e: the exponential operator.

The specification for an empirical estimation of the model can be obtained by taking the natural log of equation (7.1) and rearranging it accordingly:

$$\Delta(\ln Y) = \alpha + \beta D_{nffs} + \mu D_{ffs} + \gamma\Delta X + \delta\Delta Z \quad (6.2)$$

where: $\Delta(\ln Y) = (\ln Y_1 - \ln Y_0)$

Unlike in models that are based on cross sectional data, panel data allow for the unobserved effects a_i, to be correlated with the explanatory variables (Wooldridge, 2000). This is because a_i is assumed to be constant over time, hence one can compute the difference in the observed parameters over the two years.

The equations for period 2 (6.3) and period 1 (6.4) are as follows:

$$Y_{i2} = (\delta_0 + \alpha) + \gamma_2 X_{i2} + a_i + u_{i2} \quad (6.3)$$

$$Y_{i1} = \delta_0 + \gamma_1 X_{i1} + a_i + u_{i1} \quad (6.4)$$

Subtracting the equation (6.4) from equation (6.3) results:

$$\Delta Y_i = \alpha + \gamma\Delta X_i + \Delta u_i \quad (6.5)$$

where: Δ denotes the change from period 1 (t=1) to period 2 (t=2), Y_i is the dependent variable, X_i are independent variables and u_i is the error term. The unobserved effect, a_i, does not appear since it has been differenced away. The resulting intercept (α) denotes the change in the intercept between the two periods.

Extending the analysis to three periods (t= 1, 2, and 3), the procedure is analogous as shown in equation (7.6):

$$Y_{it} = \delta_1 + \delta_2 d2_t + \delta_3 d3_t + \gamma_1 X_{it1} + ... + \gamma_k X_{itk} + a_i + u_{it} \quad (6.6)$$

Equation (6.6) includes dummies for two periods, d2 and d3. The intercept for the first period is δ_1 for the second period it is $\delta_1 + \delta_2$. For period three the definition of intercept is analogous. In the t=3 case, time period one is subtracted from time period two and time period two from time period three resulting in 7.7:

$$\Delta Y_{it} = \delta_2 \Delta d2_t + \delta_3 \Delta d3_t + \gamma_1 \Delta X_{it1} + ... + \gamma_k \Delta X_{itk} + \Delta u_{it} \quad (6.7)$$

for t=2 and t=3. Equation (7.7) contains the differences in the time period dummies, $d2_t$ and $d3_t$; i.e. for t=2, $\Delta d2_t = 1$ and $\Delta d3_t = 0$; for t=3, $\Delta d2_t = -1$ and $\Delta d3_t = 1$. Re-writing equation (6.7) displays the intercept of the equation, which is a measure of the growth in performance of the control group:

$$\Delta Y_{it} = \alpha_0 + \alpha_3 d3_t + \gamma_1 D_G + \gamma_2 D_N + \gamma_3 \Delta X_{it3} + ... + \gamma_k \Delta X_{itk} + \Delta u_{it} \qquad (6.8)$$

for t=2 and t=3, the estimates of the γ_j are identical in both equation (6.7) and (6.8).

Applying these growth models to those performance parameters, which have passed the test of the linear model introduces a more rigorous test on the impact of FFS training.

6.4 Results

6.4.1 Linear shift effects from the FFS training

Table 6.1 summarizes the results of the t-test comparing before and after differences for the three groups of farmers. For the FFS farmers significant shifts were observed in all parameters except the gross margin from rice production. FFS farmers significantly reduced their pesticide use in gram active ingredient by 41.7 % after the training while no significant reduction was observed between the two other groups. Due to the pesticide reduction the two other parameters linked to pesticide use, i.e. farmer net benefit and EIQ also showed significant differences. The difference in the EIQ however is also influenced by a change in the type of pesticide used, i.e. FFS farmers after the training opted for less toxic pesticides. Results for rice yields were less conclusive as they increased among all three groups of farmers. It must be recognized however that FFS training gives emphasis to the pest management aspects of rice production so that yield effects are difficult to attribute as several confounding factors such as promotion of new varieties can come into play. This problem is compounded in gross margin differences where changes in the use of other inputs can take place.

Table 6.1: Summary of short-term linear shift effects from FFS training.

Farmer group	Total knowledge in rice & pest management [score]	Yield [kg/ha]	Pesticide use (gr. a.i./ha) [$/ha]	Gross margin [$/ha]	Farmer net benefit [$/ha]	Environ-ment impact [score]
FFS	**	*	***	ns	**	***
Exposed	ns	*	ns	ns	ns	ns
Control	ns	**	ns	ns	ns	ns

Note: *, **, *** indicates the difference of before and after training at 0.10, 0.05 and 0.01; ns = not significant

6.4.2 Two period growth model

Based on the methodology outlined above the analysis was proceeded by testing for change in performance in the growth rates of impact parameters. Here we included just two impact measures, namely quantity of pesticide use and EIQ. We discarded the gross margin because t-test results were non significant. Likewise we did not include yield because the somewhat ambiguous t-test results. We also ignored the net benefits because the results strongly depend on pesticide reduction, which was included.

The results of the two period growth model using the change in pesticide expenditures as the dependent variable show that FFS training has a significant effect on reducing farmers' pesticide use (see table 6.2). This result is supported by the significant coefficient for rice and pest management knowledge. The positive sign of the constant term indicates that pesticide use is likely to continue to grow without FFS. Since the dummy variable for non-FFS is non-significant there is no change in the trend of pesticide use among exposed farmers. The results questions whether FFS training has indeed a diffusion effect and thus confirms the results Feder *et al*., (2004) found in Indonesia. Summarizing the hypotheses tests in the lower panel of the table shows that a change in the positive trend in pesticide use is attributable to FFS. FFS farmers have significantly lower pesticide expenditures when compared to the non-FFS and control farmers on the short term (Table 6.2).

Using the environmental impact quotient as a dependent variable in the two period model also confirms the results of the t-test. FFS participation reduces the trend in the negative consequences of pesticides on environment in the short term (Table 6.2). As measured through the FFS participation dummy, the growth rate in EIQ of the FFS farmers shows a significant decline. It is also interesting to note that the counterfactual scenario (no FFS training) shows growing negative environmental impact from pesticides. This can be concluded from the intercepts of the models, which were significant at the 0.01 % level in the short term. Again, within villages diffusion towards more environmentally benign pesticide use practices does not seem to be sustained as shown by the non-significant variable for Non-FFS.

Table 6.2: Impact of FFS on pesticide expenditures and environmental impact quotient in the short term, two period growth model.

Two periods growth model	Δ in Pesticide costs	Δ in EIQ
Constant (α)	0.248	2.340
	(1.576)	(3.096)***
Dummy for FFS (μ)	-0.485	-1.685
	(-2.368)**	(-1.715)*
Dummy for Non-FFS (β)	-0.220	-1.008
	(-0.937)	(-0.895)
Knowledge on rice and pest management	-0.030	-0.133
(ln ΔK)	(-2.593)**	(-2.421)**
Total labor use (ln ΔL)	0.052	0.160
	(3.911)***	(2.498)**
R2	0.109	0.064
F-statistics	7.236***	4.005***
Durbin-Watson statistic	1.853	1.883
N	241	241

Note: data in parenthesis are the t-value. Pesticide expenditures are converted to real value.

6.4.3 Three period growth model

To test for the long-term effects of FFS training a three period growth model (see Wooldridge 2000) was used. Two time period dummies are included as explanatory variables.

The long-term effects of FFS on farmer's pesticide use confirm the results of the short-term effect. Hence, FFS farmers retain their improved judicious pesticide use practices and continue to reduce pesticide use over time. By contrast, no significant change can be observed for the non-FFS farmers and the control farmers in either period. Again change for both on the short and the long term knowledge had a significant effect on pesticide reduction.

For the EIQ parameter the long-term change followed the results of pesticide use expenditures. On the long term FFS farmers not only reduce pesticide use levels but also continue to adopt safer products and knowledge seems to be a major driver for this process. On the other hand, no significant change can be observed for non-FFS farmers. The counterfactual scenario however indicates that there may indeed be an overall trend towards less harmful pesticides as indicated in the time period dummies (Table 6.3).

Table 6.3: Impact of FFS on pesticide expenditures and environmental impact quotient in the short term, three period panel data growth model.

Three periods panel data growth model	Δ in Pesticide costs	Δ in EIQ
Period 2 Dummy	-0.001 (-0.006)	1.365 (2.798)***
Period 3 Dummy	0.077 (0.730)	-1.894 (-4.063)***
Dummy for FFS	-0.254 (-2.167)**	-1.869 (-3.616)***
Dummy for Non-FFS	0.137 (1.219)	0.041 (0.068)
Knowledge on rice and pest management (ln ΔK)	-0.229 (-2.517)**	-0.073 (-0.181)
Total labor use (man-day) (lnΔL)	0.445 (10.561)***	1.060 (5.698)***
R^2	0.448	0.294
F-statistics	28.183***	11.505***
Durbin-Watson statistic	1.817	1.467
N	188	188

Note: data in parenthesis are the t-value. Pesticide expenditures are converted to real values.

6.5 Conclusions

Results show that farmers who participated in the Farmer Field School retain their knowledge and continue to practice improved IPM practices. Growth rates of pesticide expenditures and environmental impact are significantly reduced by the FFS training both in the short and long term. On the other hand farmers not trained in FFS tend to continue non-judicious ways of using chemical pesticides. Thus for rice production in Thailand, the Farmer Field School is an effective method to reduce uneconomical use of chemical pesticides and make farmers adopt more environmentally benign and healthier pest control practices. Thus this study confirms some of the finding of other studies on Farmer Field Schools (e.g. Tripp 2005, van den Berg and Jiggins 2006). In addition changing farmers' pesticide use practices can generate environmental benefits that not only accrue to the farmers but to society at large. However, the direct economic benefits of farmers expressed in terms of gross margins are difficult to detect and may be small. One reason could be that in technologically advanced rice production systems possible yield gains are small and hardly measurable by means of recall surveys. Also pesticide use does not account for a high share of the variable costs and therefore gross margin differences can be confounded by other factors. Besides increased productivity effects of chemical pesticides through better timing are small unless there are pest outbreaks, which however did not occur during the years that the surveys were conducted.

Using difference in difference growth models to panel data reveals the factors that cause a change in pest management technologies. At the same time new questions arise. For example what is the driving force for farmers to adopt IPM in a crop like rice if the effects on profit are insignificant? It appears however that with pesticides, small farmers in developing countries may adopt new pest control methods even though the effects on profit may be low, because of other benefits. Several studies have shown that small farmers reveal a “willingness to pay” for less harmful pest control methods (e.g. Cuyno et al 2001, Garming and Waibel 2006). On the longer term, better informed farmers will make economically and ecologically sound crop and pest management decisions that can also help to reduce the probability of pest outbreaks. For future impact studies, a comprehensive assessment of the benefits of IPM that go beyond the short-term profit effects is recommended.

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7 Investment in Training Farmers to reduce excessive Pesticide Use in Agriculture[5]

7.1 Introduction

The use of pesticides in world agriculture continues to grow despite of upcoming biotechnology options to control pests. While pesticides have contributed to productivity growth in agriculture, often their use is excessive and injudicious. This has led to many undesirable side effects for the environment and human health resulting in additional costs for the society and for our future generation.

One possibility to reduce the use of pesticides towards a level defined as optimal from an overall economic point of view that also takes into account society's goals is investment in human capital. To practice need-based pesticide applications farmers must understand the principles that underpin the interactions driving a crop ecosystem. In order to generate this understanding a training method is required that includes participatory, field-based and experiential learning. The Farmer Field School concept (FFS) is such a training method that has been used in many developing countries.

The overall objective of this study is to investigate the economic efficiency of investment in training farmers following the FFS concept in Thailand. In addition, the results of the Thai project are compared with the identified impact of FFS and IPM training projects in other countries.

7.2 Existing evidence on the impact of IPM training on the global level

Controversy exists over the impact of IPM programs in developing countries. Although high expectations about potential benefits of IPM were raised (see e.g. Kenmore 1997) scientific evidence of large-scale IPM adoption remains sparse. While research has demonstrated that there are considerable benefits of reduced pesticide use especially in rice production (Rola and Pingali 1993, Uphoff, 2002) generally farmers continue to use high levels of pesticide. There are even claims of IPM

programs producing results opposite to expectations. The controversially discussed study of Feder *et al*., (2004) claimed that in Indonesia pesticide use

[5] Paper presented at the International symposium on "The Uses and Effects of Pesticides in Thailand: Ecological, Biomedical and Economic" 11-13 December 2003, Queen Sirikit Botanic Garden, Chiang Mai, Thailand.

increased while at the same time yields declined even among those farmers that have been trained in IPM practises in Farmer Field Schools. However, care must be taken with a far-reaching interpretation of these results for at least two reasons. Firstly, their study refers to a project implemented by the World Bank in Indonesia where the FFS farmers were identified in retrospect by a recall survey. This could have led to problems in defining FFS participants. Secondly, a rather extreme year has been used for comparison which could be one reason why the authors have found lower yields for FFS and Non-FFS farmers several years after the training had been conducted.

A recent analysis of FFS-IPM projects around the world (Van den Berg 2004) did not confirm the results of the Feder study. In this review the type of IPM impact was classified according to its effect on yield and pesticide use. While in the most intensive cropping systems IPM will normally lead to pesticide reduction, there can be an indirect effect of the training on yield either due to a better targeting of pest control measures or because farmers might have become more efficient in their use of other inputs. Based on these effects, three types of impacts can be specified as follows:

1. Yields increase and pesticide use decreases
2. Yields remain unchanged or decrease or while pesticide use decreases.
3. Yields increase and pesticide use remain unchanged or even increases

The majority of analyzed projects (58.6%) falls into one of these impact categories, however in over 40 % of the sample projects no information on changes in yield or pesticide use was available.

As shown in table 7.1 almost half of the projects where information was available showed that FFS led to increase in yield and at the same time pesticide reduction. Comparing the projects by crop types, e.g. rice, vegetables, and others (e.g. tea, cotton and various crops), half of the FFS projects in rice led to yield increase and to pesticide use reduction.

Table 7.1: Results of past economic impact assessment for FFS by Crop

Category	Crops			Total
	Rice	Vegetables	others	
Yield increase and pesticide reduce	4 (23.5%)	2 (11.8%)	2 (11.8%)	8 (47.1%)
Yield unchanged or decrease and pesticide reduce	4 (23.5%)	1 (5.8%)	2 (11.8%)	7 (41.1%)
Yield increase and pesticide increase or unchanged	0 (0.0%)	0 (0.0%)	2 (11.8%)	2 (11.8%)
Total	8 (47.0%)	3 (17.6%)	6 (35.4%)	17 (100.0%)

Source: Calculated based on information collected by Van den Berg (2004)

Grouping the sample of Farmer Field School projects by the stated objectives, the result show that most projects fall into the category "pesticide reduction" even when including this where there was no information (Table 7.2) which not in all cases was pesticide reduction.

Table 7.2: Results of past economic impact assessment for FFS by training objective.

Pesticide use	Training objectives			Total
	Increase Net Benefit	Change in knowledge and Practices	Others	
Pesticide reduction	8 (27.6%)	6 (20.7%)	1 (3.4%)	15 (51.7%)
Impact not known	2 (6.9%)	4 (13.8%)	8 (27.6%)	14 (48.3%)
Total	10 (34.5%)	10 (34.5%)	9 (31.0%)	29 (100.0%)

Source: Calculated based on information collected by Van den Berg (2004)

7.3 Source of Data

The data on costs of implementing FFS in Thailand were collected from the implementing agency, the Department of Agricultural Extension (DOAE). For up-scaling estimates national statistical data were used.

The data to quantify the benefits of FFS are drawn from a standardized questionnaire by interviewing farmers prior and after the FFS, 241 respondents as explained in chapter 2.

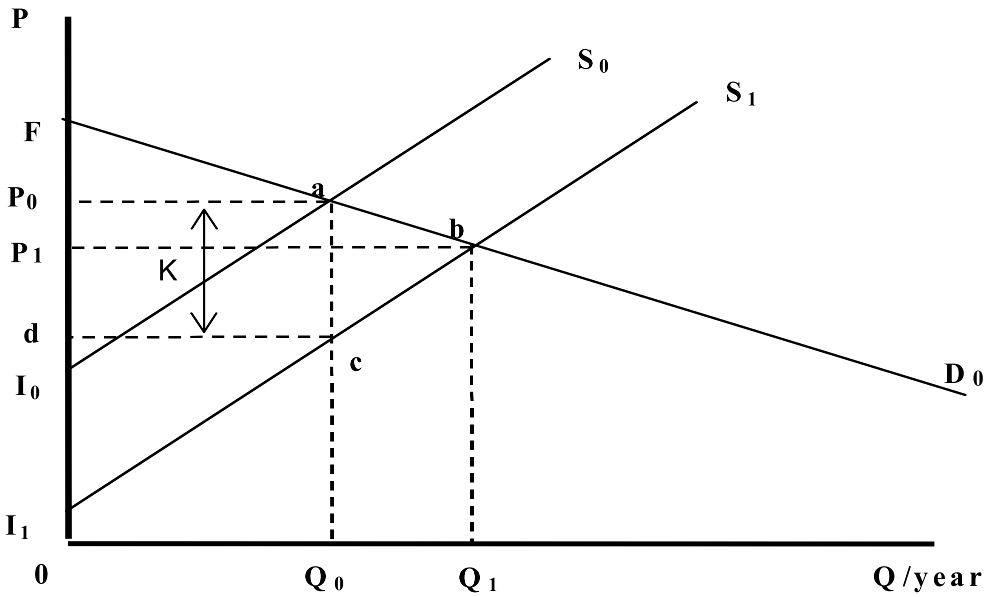
7.4 Analytical framework

The major framework to assess the benefit of the program level impact uses the concept of economic surplus.

Economic surplus is the summation of consumer and producer surplus. The concept of consumer surplus was defined as the difference between the sacrifice which the purchaser would be willing to make and the purchase price he has to pay in exchange (Hanley and Spash, 1993) or consumer surplus is the area below the compensated demand curve and above the price line and can be approximated as the area below the Marshallian demand curve and above the market price. Producer surplus is measured as the area below the price line and above the compensated supply curve and can be approximated as the area below the market price and above the (Marshallian) supply curve. Then, total economic benefits are measured as the summation of the consumer surplus and producer surplus areas.

Figure 7.1 illustrates the impact of a research and extension induced shift in supply on producer and consumer welfare. The initial equilibrium price and quantity are P_0 and Q_0, respectively. Consumer surplus is equal to FaP_0 and the producer surplus is equal to P_0aI_0. Total welfare is equal to FaI_0, which is the sum of consumer and producer surplus. Cost-reducing or yield-increasing research and extension technologies will result in a rightward shift in the supply curve from S_0 to S_1, resulting in a new equilibrium price (P_1) and quantity (Q_1). Because of the changes in the equilibrium prices and quantities, there will be changes in the level of welfare occuring to producers and consumers and a change in total economic welfare. The change in consumer surplus (ΔCS) from the research or extension induced supply shift is equal to the area P_0abP_1. The change in producer surplus (ΔPS) is equal to the area P_1bI_1 minus the area P_0aI_0, which, in the case of linear supply curves moving in a parallel fashion, is equal to the area P_1bcd. The change in total economic surplus (ΔES) is equal to the area I_0abI_1 which, in the case of a parallel supply shift, is equal to the area P_0abcd. (Templeton and Donald, 2003)

Figure 7.1: Welfare effects of technology introduction.



Source: Aston, Norton and Pardey, 1995, p. 41

The changes in economic welfare can be expressed algebraically as follows (Alston, Norton and Pardey, 1995: 210):

$\Delta CS = P_0Q_0Z(1+ 0.5Z\eta)$

$\Delta PS = P_0Q_0(K - Z)(1+ 0.5Z\eta)$

$\Delta ES = \Delta CS + \Delta PS = P_0Q_0K(1+ 0.5Z\eta)$

where K is equal to the vertical research-induced shift in the supply curve measured as a proportion of the initial equilibrium price,

Z = $K\varepsilon/(\varepsilon+\eta)$ and ε and η are the elasticity of supply and the absolute elasticity of demand, respectively (Alston, Norton and Pardey 1995, p.211). The DREAM model (IFPRI, 2000) allows the calculation of changes in economic surplus from technology introduction resulting in a shift of the k factor. DREAM stands for Dynamic Research Evaluation for Management. DREAM is designed to evaluate the economic impacts of agricultural research and development for a broad range of policy, marketing technology and adoption conditions. The objective of DREAM model is to provide analysts with a practical means of generating relevant and structured information to support strategic decision making (IFPRI, 2000). In the case of FFS the reason for the shift of the supply curve is assumed to be the improvement of pest management knowledge.

Farmers who apply the knowledge gained in FFS better understand ecosystems principles and will therefore change their crop management practices. Such practices will eventually lead to the reduction of excessive pesticide use thus affecting the marginal cost curve of farms and hence the supply curves of the commodity where the program was introduced.

The results presented here show the benefits of IPM FFS training program measured as economic surplus. It must be noted that this measure is likely to underestimate the true benefits because the positive effects of reduced pesticide use on human health and environmental resources are not included in this analysis.

7.5 Results

The results are presented in two main parts. The first part describes the administrative process of introducing the FFS project in Thailand. Thereafter, farm-level impacts of IPM farmer field schools and a program benefit-cost analysis of the above program are performed.

7.5.1 National IPM Farmer Field schools in Thailand

In Thailand, the Department of Agricultural Extension (DOAE) has included FFS into the National Extension Service activities under the responsibility of the Institute of Biological Agriculture and Farmer Field School. Field school facilitators had been trained already by previous IPM programs of the early nineties. However implementation has not been very intensive until recently. Implemented by the National IPM Program in Thailand pilot field schools started during 1999/2000. The applied concepts basically followed those in Indonesia and the Philippines. In general, field schools ran for the long period of 16 weeks, once a week and half-day basis. The FFS model is expected to stimulate farmers to discover the agro-ecosystems principle, which underpin a rational decision-making in crop and pest management. FFS wants to offer a different extension method as compared to the classic extension concept which tried to promote a predetermined set of technical recommendations.

Although some authors reduce IPM to be a technology that can simply be adopted (Van den Berg, 2004), to measure its productivity impact requires advanced quantitative analysis. In the next step the farm level benefits are assessed in order to provide the statistical basis for estimating the assumed shift in the supply curve.

7.5.2 Farm-level analysis

Farmers who participated in the training have significantly lower pesticide costs as compared to the non-participants and the control group. This is true for all types of pesticides including herbicides, molluscicides, and insecticides while the difference is non-significant for fungicides (Table 7.4). Comparing rice yields these were not significantly different among the three groups of farmer, neither before nor after the training season. This indicates that in terms of productivity, similar conditions have prevailed. However, rice yields were significantly higher in all three groups in the season after the training. Hence, in the Thailand case training did not result in positive yield effects, although at a yield level of 4 t per ha with the use of high yielding varieties in irrigated rice improvements seem to be possible. Likewise, net returns from rice production do not differ significantly, neither when comparing before and after training nor among the three groups. This is probably because the only significant difference is in pesticide costs and in rice these constitute only a small percentage of the total variable costs. In conclusion, only pesticide reduction effects can be assumed for the programme level analysis which nevertheless cause a reduction in farmers' marginal costs and therefore ignite a shift in supply.

Table 7.4: Comparison of average pesticide costs by type of pesticide and farmer group.

Items and Unit (Baht/rai)	Before training	After training	t-test	% change
1. Herbicide	31.16	25.10	2.471**	
- FFS farmers	40.42	35.46	0.952 *ns*	19.45
- Non-FFS farmers	40.58	34.79	1.199 *ns*	
- Control group	1.111 *ns*	2.062 *ns*		
F-test				
2. Molluscicides	41.26	16.86	2.142**	
- FFS farmers	33.78	35.35	-0.215 *ns*	59.14
- Non-FFS farmers	22.52	26.93	-0.976 *ns*	
- Control group	1.023 *ns*	4.766***		
F-test				
3. Insecticide	41.19	17.26	3.451***	
- FFS farmers	50.27	49.79	0.056 *ns*	58.10
- Non-FFS farmers	31.68	28.41	0.594 *ns*	
- Control group	0.784 *ns*	7.108***		
F-test				
4. Fungicide	17.75	14.14	0.945 *ns*	
- FFS farmers	18.02	27.91	-2.007**	20.39
- Non-FFS farmers	15.03	20.56	-0.945 *ns*	
- Control group	3.756**	2.807*		
F-test				
5. Total pesticide	153.47	83.03	4.201***	
- FFS farmers	175.19	159.10	0.987 *ns*	45.90
- Non-FFS farmers	143.88	124.56	1.508 *ns*	
- Control group	0.349 *ns*	5.557***		
F-test				

Note: * significant at 90%; ** significant at 95%; *** significant at 99%; *ns* = non-significant difference

7.5.2 Program-level analysis

The benefits derived from IPM FFS program in Thailand are estimated according to the shift in the supply curve for rice as a result of the reduction of chemical pesticide use. This shift occurs because farmers are assumed to reallocate the savings from pesticides into other output increasing inputs. These benefits are quantified using secondary data as well as the results of the survey. The survey results indicate that the percentage reduction of chemical pesticide use due to the training program ranges from 19-59% (Table 7.5). To be rather conservative for the scaling-up estimation of the pesticide use reduction at the program level, a 10% reduction was assumed resulting in equivalent shift in the supply curve[6]. Maximum adoption was assumed to reach 2 per cent of the rice farmers in Thailand. Here drop out farmers were excluded and adopters were assumed to realize the average benefits derived from the pilot areas. Adoption was assumed as sigmoid curve reaching its maximum after 30 years equivalent to the time horizon of the analysis.

Table 7.5: Major assumptions for benefit assessment of FFS program in Thailand using the IFPRI-DREAM model.

Items and unit	Unit	Amount
Total rice production in 1999/2000 a	1,000 tons	23,529.00
Total rice production of ROW in 1999/2000 [b]	1,000 tons	622,223.00
Quantity of rice consumption of Thailand in 1999/2000 [a]	1,000 tons	13,694.00
Quantity of rice consumption of ROW in 1999/2000 [b]	1,000 tons	632,058.00
Price of rice in Thailand in 1999/2000 [a]	Baht/ton	4,856.00
Price of rice of ROW in 1999/2000 [c]	Baht/ton	5,862.33
Price elasticity of rice supply in Thailand		0.23
Price elasticity of rice demand in Thailand		-0.43
Percentage of supply shift (k-shift) [e]		10.00
Maximum percentage of adoption		2

Note: ROW: rest of the world. Rice production here refers only to the long grain rice that is mainly produced.
Source: a Office of Agricultural Economics (1995, 1996 and 1998)
b United States Department of Agriculture (2001b)
c United States Department of Agriculture (2001a)
d Isvilanonda and Poapongsakorn (1995)
e estimated data from the survey results explained in the above paragraph

In addition to the parameters of Table 7.5 further assumptions were made. First, it was assumed that a one year research and development lag was required for the IPM FFS training program to be implemented. The success

[6] The net research impact from changes in production costs and yield in the case of successful research and extension, expressed as a net percentage decrease in unit production costs can be calculated using the following formula (IFPRI, 2000).

Net shift = [change in yield / elasticity of supply] – [change in cost / (1+ change in yield /100)] rate was assumed to be 50%, i.e. effectively doubling the cost of FFS implementation. The program costs were collected from the Department of Agricultural Extension (Table 7.6).

Table 7.6: Actual and estimated costs of the IPM FFS training program in Thailand in Baht per year

Year	FFS training activities	TOT training activities	Policy workshop Evaluation	Other Administra-tive costs	Total
1999	1,290,000	2,187,500	400,000	700,000	4,579,499
2000	1,260,000	6,348,000	400,000	700,000	8,710,000
2001	4,500,000	4,755,000	400,000	700,000	10,357,001
2002	0	0	730,000	0	732,002
2003	2,520,000	0	400,000	700,000	3,622,003
2004	3,780,000				3,782,004
2005 to 2028					4,000,000

Source: DOAE (2003)

7.6 Cost-Benefit Analysis

The base model was calculated for a time period of 30 years, using the discount rate at 8%. The results of base scenario indicated that the consumer surplus is estimated at 98,377,850 Baht and the producer surplus is about 213,066,460 Baht. Hence, total present value of benefits equal to 311,444,310 Baht and total present value of costs are 56,004,380 Baht. Hence, the net present value (NPV) is about 255 million Baht over the 30 years, with the benefit-cost ratio (BCR) of 5.56 and Internal rate of return (IRR) of 27.28% (Table 7.7). Therefore, the investment in the program level is economically feasible.

Additional scenarios were included in the analysis in order to test the stability of the results as follows:

1. A 1.7% pesticide reduction and zero yield increase.
2. A 1.7% pesticide reduction and a 1% shift in yield
3. No reduction of pesticide use but a 2 % yield shift
4. No more FFS training after year 2004 with adoption continuing 2 more years

In the first scenario the net present value becomes negative (Table 7.7). That is to say, if the IPM FFS has no yield effects the total pesticide reduction in Thailand's rice production required to justify this public investment must be just under 2 %. In the second scenario the NPV turns positive, i.e. yield effects from FFS training play an important role. The third scenario shows that without pesticide reduction, a yield increase of at least 2 % is required to have a positive NPV. Such output effect seems unlikely considering that this is above the average annual rate of productivity growth due to plant breeding.

In the last scenario it was assume that the Thai government would stop support for FFS training after 2004 the NPV is still clearly positive corresponding to a benefit-cost ratio (BCR) of 1.22. Hence, for every Baht the Thai government has spend on FFS a social benefit of 1.22 Baht is obtained.

It must be pointed out that the benefits for the pesticide reduction scenarios are still underestimated because external costs of pesticides were not considered. Also, additional benefits could arise because the positive effect on farmer education may enable them to act more efficiently and make more informed and therefore better decisions, for example, when new technology such as genetically modified crops will be introduced. Hence, it can be assumed that past investments in FFS IPM are likely to pay off. However, if we assumed no training after year 2004 with no more adoption, the NPV will become negative. This points out that a retaining of farmer practice in the long run is important. The result of this analysis are similar to those found by Waibel and Garming (2005) for IPM investment in Nicaragua where efficiency of investment was crucially dependent on government commitment to training.

Table 7.7: Investment analysis of the IPM FFS program in Thailand for different scenarios.

Scenarios	NPV (Baht)	BCR
Base scenario (10% pesticide reduction, no yield increase)	255,439,930	5.56
1.7% pesticide reduction, no yield increase	-3,062,270	0.95
1.7% pesticide reduction and yield increase at 1%	27,457,940	1.49
No pesticide reduction but yield increase at 2%	6,280,610	1.11
No training after 2004 and assumed adoption continued 2 more years	5,947,700	1.22

7.7 Conclusions

Available evidence from public investment in FFS training in rice in Thailand suggests that such programs can be effective in changing farmer pest control practices and especially reduce uneconomical pesticide use. However, few cost benefit analyses are available that could show the efficiency of such public investment. The analysis of public investment in IPM FFS in rice in Thailand shows that even under conservative assumptions a positive net present value of such public investment can be achieved. Most likely, past investments in farmer training in Thailand paid off. Nevertheless, some questions still remain. For example, what is the effect on output from FFS training, are farmers reallocating the amount saved from pesticides in other yield increasing inputs. Does the government continue to be committed to FFS training in view of other potential technological solutions? What mechanisms can be used to achieve a more rapid up-scaling of IPM FFS training or should this concept only be applied to special situations, e.g. where excessive pesticide use persists?

Overall our results suggest that the viability of investment in Farmer Training depends whether IPM practices continue to be practices in the long run. Furthermore, it seems obvious that any policy incentives to increase productivity of rice, distortions in favour of pesticide use (such as subsidies and aggressive advertisement of chemical pesticides should be avoided as such conditions will lower the likelihood of sustainable FFS adoption. Finally, further benefits of FFS like farmer health and positive environmental effects from pesticide reduction should be included in the analysis. The assessment of FFS training should also go beyond the concept of economic efficiency and consider other welfare effects like making farmers less vulnerable when reducing the probability of pest outbreaks or empowering them against technology introductions that are driven by private interests not compatible with those of farmers and the society.

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8 Synthesis and Outlook

The collection of papers presented as chapters in this book analyse various angles of the Farmer Field School program in Thailand. It was shown that FFS can be an effective and efficient strategy to advance knowledge among rice farmers. Therefore, public support for FFS is justified. Unfortunately, to date the Department of Agricultural Extension (DAOE) only loosely supports this programme. As pointed out in chapter 1 of the book, while FFS are mentioned in the DOAE policy procedures, actual support in terms of budget and programming is minimal. The dissolution of the BAFFS and the placement of the FFS programme under the responsibility of the pest management division of DOAE has been “downgraded” to just another ordinary programme, of which DOAE had so many in the past. Clearly, FFS has lost its special status, which it had obtained during the time period following the intervention of the King of Thailand.

The change in thinking at the level of extension officers introduced by the FFS concept that Thai rice farmers are not “subordinates” but are actually their partners in the agricultural development process was perhaps not sustainable. Many agricultural officials still do not entrust farming communities the ability to conduct own collective pest control actions without public sector supervision. The lack of change in attitude towards farmers bears the danger that the outbreak budget, which has practically been abolished, could come back. A backward-looking pesticide and IPM policy could be driven by vested interests of those groups, which benefit from the subsidy system of the past.

The data collection activities of this research presented in chapter 2 posed a real challenge. Collection of panel data requires interviewing the same respondents at different points in time. In this study the farmers were interviewed at three times in a period of four years. In this way the data requirements of developing a difference in difference (DD) model was met. Hence, the first round took of data collection took place before the training in February 2000, which was at the end of the wet rice-cropping season. The second survey was then carried out a year later. This was after the training and the FFS farmers had a chance to apply their new knowledge for the first time. Again two years later the third survey was carried out. It is planned to conduct a last survey in 2008 that would allow to establish the long term picture of impact.

It was shown that collection of panel data could create all kinds of problems. In the case of this study a heavy flood affected two FFS villages in the season in which the survey was referring to. Some of the FFS farmers suffered from very low rice production because of the water logging effect and thus pest management was not an issue in that season. Of course one could argue that from a theoretical point of view any random events even will be differenced away if these shocks are of clear covariate nature i.e. they take place in the control village as well. One could also argue that FFS training should make farmers to become better decision-makers and therefore also enable them to be better crisis managers. While this may be theoretically correct, there are some simple practical problems, which were encountered in the course of the surveys that made it difficult to establish empirical proof for such hypothesis. One problem is that farmer respondents who have just experienced shocks from natural disasters are often simply unwilling to answer questions on a topic that is currently unimportant to them in the light of other more important issues. Forcing interviews on other topics can cause biases. In the present study the number of valid cases had to be reduced from 241 after the second survey to 122 for the third survey. However, this still left a reasonable sample size for the three period panel model.

The paper presented in chapter 3, provides some empirical evidence of existing overuse of pesticides in rice production in Thailand. It uses the methodology of damage control functions. In this methodology a distinction was made between direct productive inputs e.g. land, labour and capital, and damage abatement factors like pesticides, which are inputs that do not increase the output directly. The contribution of damage abatement agents depends on their ability to increase the share of potential output that farmers realize by reducing damage from pests. Damage control equations are therefore a more powerful tool to assess the productivity of pest control inputs as compared to the conventional production function model for example using Cobb-Douglas functions.

Damage control equations results found in this study confirm that previous productivity assessments using conventional production function approaches tended to overestimate the productivity of pesticides. Results of this study therefore provide a scientific argument why policies to reduce pesticide use are economically justified. It lends support to those forces in the agricultural decision-making process that aim at removing the hidden and indirect subsidies of pesticide use. In fact there are two arguments why the existing levels of pesticide use, in particular insecticides, in rice production in Thailand are above the socially optimal level.

The first argument can be taken from the damage function results: pesticides in rice are less productive than conventional wisdom would suggest. The second argument comes from evidence of negative externalities. As established by Jungbluth (1995) for every Baht spend on chemical pesticides in Thai agriculture approximately the same amount can be added to account for externalities. Thus, chapter 3 underpins that a concept like farmer field schools is worthwhile to be considered but at the same time underlines the need for rigorous impact assessment.

Chapter 4 presents the first steps towards applying a rigorous impact assessment methodology. As a knowledge-intensive new technology, impact assessment of Farmer Field Schools provides a challenging case for economists. However, such studies are necessary for reasons of accountability and planning. Although some of the promoters of FFS may deem such efforts to be unnecessary, so far very little quantitative evidence exists as regards the benefits of FFS. This analysis presents a first attempt to explore the different angles necessary for carrying out an economic analysis of FFS. In this paper, the analysis is limited to the income effects on farm level. The analysis of the effects of FFS on income is carried out in two steps. The first step was to perform multiple group comparisons, which showed that FFS can be an effective means to reduce uneconomical pesticide use of rice farmers. However, the results are less clear with regards the effect of FFS on rice yields. In irrigated rice in Asia rice it has always been proven to be difficult to show yield increasing effects of FFS. This is perhaps due to the generally high level of productivity and the relatively minor effects on rice pests on yield unless there is a severe pest outbreak.

The second step was to a profit function approach including a primal profit, output supply and input demand functions using data of the first and the second survey as described in chapter 2. The different functional specifications assumed to represent possible effects from FFS training were consistent with assumed economic behaviour. Hence, results can be applied for testing the hypothesis that raising farmers' ecosystems understanding through Farmer Field Schools can increase productivity of rice growing.

Results confirmed that FFS participants on the short run reduced their pesticide inputs. This is perhaps not surprising as the training puts emphasis on alternative methods of pest management. However, it also appears that both farm profits and yield can be increased by enhancing farmer's knowledge and by enhancing their understanding of ecosystems as emphasized by FFS. Nonetheless, statistical evidence for these observations is weak. A larger number of field schools are necessary than the five pilot project available in this study. Hence based on the profit function approach as applied in this chapter, no final conclusion can be drawn regarding the benefits of FFS. The analysis cannot answer the question whether knowledge will be retained and the change in pesticide use practices is sustainable. This question however is tackled in chapter 6.

In chapter 5 the factors affecting participation in the Farmer Field School activities have been studied. Like in any education program one major issue, which determines success is quality. Quality of the training process is multi-dimensional but one factor is attendance. If participants do not regularly attend the training sessions it is unlikely that the very idea of an FFS, which is to promote an experiential learning process that leads to a better understanding of the rice agro ecosystem can be realized. However, such paradigm shift is essential if one can reasonably assume that farmers, as a result of FFS change their attitudes towards pest control and apply pest management practices based on IPM principles. The training quality question is especially important if the program is implemented on a large scale where maintaining high quality standards may become a problem. Given the high costs of FFS, relative to ordinary agricultural extension activities, FFS may not be economically justifiable as a nationwide program.

The analysis presented in chapter 5 has shown that two factors are important incentives for the participants of FFS to attend the training sessions as scheduled: (1) their level of pesticide costs and (2) the quality of the training process. Farmers who spend a lot on pesticides relative to their level of output do have an incentive to learn methods that help them to become more efficient. Similarly, on the supply site, a poorly administered FFS as indicated, for example, by a shorter than planned duration of the training and irregularly conducted training sessions act as a disincentive to the farmers to participate.

In the worst case, if they don't like the course they may drop out in spite of the social pressure by village leaders.

Results also suggest some conclusions regarding FFS implementation. Firstly, the demand for FFS is higher in those areas where pesticide overuse is widespread and pesticide reduction can lead to high benefits. This would be concurrent with areas where farmers practice intensive methods of farming and where so far economic considerations in the application of pesticides have been ignored. Secondly, the training quality factor suggests that minimizing the costs of FFS implementation may be at the expense of quality. A farmer field school must have a minimum standard. It must be carried out by trainers who are regularly available and who are given sufficient incentives to maintain the process at a high level.

Another factor that influences participation is prior knowledge of farmer participants. Farmers with better knowledge before the training tend to drop out less. The implications of this result is that FFS projects may tend to be biased toward the already more knowledgeable farmers. Hence, FFS may widen the gap between knowledgeable and less knowledgeable farmers. Perhaps this suggests FFS requires something like a "pre-school" to be able to live up to its full potential?

Finally, on the issue of opportunity cost of labour, there are costs on part of the farmer. Farmers may have to forgo other important activities when attending lengthy training session. Hence, the true costs of FFS exceed those indicated in the budgetary statements of governments and international donor agencies.

Chapter 6 is the highlight of the study because the most comprehensive results of impact assessment of FFS are presented. Here full use is made of the complete panel data set as described in chapter 2. The most important result is that farmers who participated in the Farmer Field School retain their knowledge and continue with their improved IPM practices. This assures the Government of Thailand that their investment has had long-term impact. It also underlines the importance of the intervention of the King of Thailand who reinforced the activities of the promoters of the FFS concept.

The methodology used to draw above conclusions is rather advanced. The model used in the analysis is a multi-period difference in difference (DD) model using panel data that allow estimating the short and the medium (long) term effects of the training. For each respondent in the sample there are three observation points over time and thus two alternative models were applied, namely a two period and a three period panel using a larger sample.

Results show that growth rates of pesticide expenditures and environmental impact are significantly reduced by the FFS training both in the short and long term, while farmers not trained in FFS tend to continue non-judicious ways of using chemical pesticides. Hence, for rice production in Thailand, the Farmer Field School is an effective method to reduce uneconomical use of chemical pesticides and make farmers to adopt more environmentally benign pesticide use practices. The study of FFS in Thailand thus confirms the finding of other studies on Farmer Field Schools (e.g. Tripp 2005, van den Berg 2005, van den Berg and Jiggins 2006). Changing farmers' pesticide use practices thus generates environmental benefits that not only accrue to the farmers but to society at large. However, as already shown in the short-term analysis, the direct economic benefits of farmers expressed in terms of gross margins may indeed be small. The lack of yield impact may, however, also be a result of measurement problems. Another possible long-term impact of FFS cannot be captured with the panel data that were collected. The technology is likely to reduce the probability of pest outbreaks but his cannot be measured with the current study design and because outbreaks did not occur during the years that the surveys were conducted. Furthermore, in the case of pest outbreaks, IPM practitioners are expected to exercise more effective control measures as they are better informed and more knowledgeable as their untrained colleagues.

In chapter 7, a cost benefit analysis has been carried out using a model of impact assessment consistent with the basic tenets of welfare theory. The so-called DREAM model, developed by IFPRI, is a welfare economics model that allows the calculation of consumer and producer surplus based on reasonable assumptions of the price elasticities of supply and demand and of the k-shift, i.e. the change in aggregate supply of rice as a result of the change in the marginal cost of production of producers. The impact assessment case study of FFS in Thailand provides a very good basis for calculating the shift in the supply curve (see chapter 3) and thus allows the calculation of the welfare effects of the government's investment in FFS. The total benefits are calculated by scaling-up the observed short-term training impact based on the average of the five pilot projects on FFS but making some conservative assumptions.

The major benefits of the IPM FFS program in Thailand are the reduction of chemical pesticide use and a reallocation of the savings from pesticides into other output increasing inputs. These benefits are quantified using secondary data as well as the results of the impact study. Regarding adoption of FFS practices conservative assumptions were made that following a classic adoption curve over a 30 year period only 2 % of rice farmers in Thailand will adopt IPM.

Results of the cost benefit analysis of the IPM FFS program in rice in Thailand showed that even under very conservative assumptions a positive net present value of such public investment could be achieved. Most likely, the investment of the Thai government in farmer training has paid off well. Nevertheless, some questions still remain. The first is the sustainability of the program. As discussed in chapter 1 some groups within the government may not be committed to continue supporting FFS training because of vested interests? Secondly, rapid up-scaling of Farmer Field Schools has always been a problem, not only in Thailand. So far there is no good public or private sector strategy for up-scaling such programs, for example, by facilitating access to some of the several rural development funds to finance training. Also, the concept of self-financing where the participants would pay for attending training (just like management courses in the business world!) is not yet known and is perhaps still a bit “far out” for agriculture in Thailand. It is also questionable if a nation-wide introduction of FFS, i.e. implementing it as a national extension strategy would be economically efficient. The alternative is to limit the introduction of the IPM FFS concept only in special situations, e.g. in pest and pesticide “hot spot areas”. These are areas with a history of pest problems and where excessive pesticide use may persist. Finally, the likelihood of maintaining an enabling and IPM friendly policy environment in Thailand is not known. Generally, while there has been some change in a positive direction, for example through the modification of the pesticide outbreak budget (see chapter 1) the prospects for maintaining such policy direction are uncertain. Politically powerful opponents for any pesticide reduction programs are the chemical companies in Thailand. They can be expected to exert lobbyist pressure to avoid their business interests being hampered.

Summarizing the results of this collection of studies about FFS in rice in Thailand some conclusions can be drawn. Firstly, while this study used an almost ideal experimental design and was among the few impact assessments of FFS where a complete panel data set could be established, questions remain. For example, the question of implementing FFS programs on a large scale needs to be investigated in connection with the possibilities of quality control and fiscal sustainability. Both factors require studying appropriate institutional mechanisms. Secondly, there are methodological issues in impact assessment of FFS that include the self-selection issues related to IPM/FFS participation, the non-market benefits attributable to lower levels of pesticide use and the utility that may be attributable to farmer empowerment effected through gaining knowledge and confidence from FFS, and their contribution to building local institutional capacity. Thirdly, in order to assure cost-effectiveness, the questions of targeting FFS deserve more attention. Given the lessons learned from this study it can be recommended that targets for IPM FFS in Asia should be primarily those areas where pesticide use is high and where they are perceived as a problem. This would also include crops where overall pest control costs are high. Under these conditions FFS can help to make pest control more economical and at the same time reduce negative externalities.

However, the concept of FFS also must be seen in a wider policy context. Instruments to reduce policy distortions against IPM, e.g. raising pesticide prices through levies or taxes to their social price levels are still an issue. As pointed out by Rhus *et al*., (1999) feasible policies creating financial incentives include cost-share programs, tax credits, low interest loans, and the provision of insurance to farmers practicing Integrated Pest Management (Stabinsky *et al*., 1994). Proposals like providing financial assistance to farmers who voluntarily switch from pesticide intensive crop protection to IPM as payment for environmental services, and because of the high initial set-up management costs resulting from path dependency needs further study.

In summary, this booklet provides evidence of FFS impact using rigorous scientific analysis. Several questions remain about FFS in IPM whose answers depend on further data and on methodological advancements of the analysis.

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