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Economic and Health Consequences of Pesticide Use in Paddy Production in the Mekong Delta, Vietnam

Nguyen Huu Dung and Tran Thi Thanh Dung

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February 1999

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ECONOMIC AND HEALTH CONSEQUENCES OF PESTICIDE USE IN PADDY PRODUCTION IN THE MEKONG DELTA, VIETNAM

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Abstract

Paddy productivity and variable factors efficiency were calculated based on a farm survey. Logit regression was employed to relate econometrically a set of farmer characteristics to indicators of pesticide exposure to identify types of health impairments that may be attributed to prolonged pesticide use. Then, the pesticides' negative effects on farmers' health were estimated by means of dose-response function. The empirical results indicated that the amount of pesticides applied was far higher than the optimal level for profit maximization. Insecticides influenced negatively and significantly farmers' health via the number of contacts rather than the total dose. Meanwhile, the higher the number of the doses and the number of applications of herbicides and fungicides, the bigger the health cost due to exposure. Since economic gains from input savings and a decrease in health cost outweighed productivity losses, a tax of 33.4 percent of pesticide price was proposed.

1.0 INTRODUCTION

Paddy rice has long been the major food crop in Vietnam, covering around 65 percent of the cultivated area. Most ecological regions manage to grow two to three croppings in a year. By far, the Mekong Delta is the biggest cultivated region in Vietnam, accounting for more than 50 percent of paddy produced in a year. Taking advantage of the changes in economic policy-orientation that took place in the late 1980s, paddy production grew rapidly at an impressive rate of 5.1 percent between 1986 and 1995. The production growth in rice, the primary staple of the population, has been more than double the population growth in 1995. This significant growth has helped to overcome the food crisis faced by the country for more than two decades and generated rice surplus that enhanced export earnings.

However, with the widespread use of high yielding varieties (HYVs) since the late 1960s, farmers have tended to increase input application over time to sustain yields under intensive cultivation systems. Thus, while an increase in yields and production could be seen at the farm level, there may have been a corresponding increase in other costs brought about by the greater dependence on chemical inputs, namely: pesticides and inorganic fertilizers. In particular, the rapid increase in the use of pesticides has posed threats to the environment such as adverse health effects on farmers and others exposed to pesticides, and pollution of drinking water and aquaculture. Further expansion and intensification in rice production, therefore, face the challenges of formulating and implementing an agricultural growth strategy that is both economically and environmentally sustainable.

2.0 ENVIRONMENTAL PROBLEMS IN PADDY FARMING DUE TO PESTICIDES

Mekong Delta is located in the southern side of Vietnam (long. 8°60'N to 10°N and lat. 104°50'E to 106°80'E), traversing 12 provinces, namely: Longan, Tiengiang, Bentre, Vinhlong, Cantho, Travinh, Dongthap, Angiang, Tiengiang, Soctrang, Baclieu, and Camau. At present, land for farming and aquaculture is about 2.6 million ha, representing two-thirds of total area of 3.9 million ha (General Statistical Office, 1995). Single and double rice croppings are dominant cropping systems in the Mekong Delta, taking up 70 percent of the agricultural land. Some 20 percent are planted to upland crops and perennials.

Under current production systems, while other pest management practices have been declining, chemical pesticide use in paddy production has been steadily increasing in Vietnam. As reported by the Plant Protection Department, pesticide use in rice accounted for 65.5 percent of total market value of pesticides in 1996. Insecticide was the most (85%) widely used pesticide among rice growers in the Mekong Delta. Fungicide use was relatively low, and only about 4 percent used herbicide (Heong et. al 1994). The high insecticide use in the Mekong Delta is closely in accordance with intensive cultivation; most insecticides are sprayed at the initial stages of the rice growing season (Mai, 1995). The farmers' management studies implemented by the National Institute for Agriculture Planning and Projection (NIAPP) provided some evidence about the overuse of pesticides in Southern Vietnam (World Bank, 1995). This trend of pesticide overuse to control the brown plant hopper had been prevalent in the Mekong Delta only. As a result, expenditures on pesticides of farmers in the Mekong Delta had been significantly higher than in the Red River Delta in North Vietnam (Table 1). The frequency of application was also greater in the Mekong Delta, although very high applications of pesticides could be seen in most rice farming regions of the country. It was applied 5.3 times per season (World Bank, 1995). The figure is rather high compared with that obtained from some study sites in the Philippines.

Table 1. Pesticide expenditures and application, 1990-1991.

Region / Country	Expenditure (USD / ha)	Number of applications
China	25.6	3.5
India	24.9	2.4
Philippines	26.1	2.0
Indonesia	7.7	2.2
Northern Vietnam	22.3	1.0
Southern Vietnam	39.3	5.3

Source: FAO, 1995

It was observed that farmers improperly applied hazardous pesticides in combination with other chemicals. Improper use and handling of pesticides had also been reported in some recent studies. Their dangerous effects on human health could already be found at the controlling level upon importation, through the wholesale process, and at the farm level (FAO, 1995). Poisoning symptoms due to use and unsafe handling of hazardous pesticides had been observed. The risk from pesticide exposures to farmers' health was expected to increase with applications because of fatal toxicity of chemical pesticides. However, the number of poisoning symptoms would be greater since in most cases farmers did not go to the hospital. On the other hand, local health officials did not often diagnose exactly poisoning symptoms due to pesticide exposures. As such, estimating health costs from pesticide use such as costs of treatment and opportunity cost of farmers' time required to recuperate was essential to consider the effect of pesticide on the environment. Health status of farmers and fish and shrimp cultivators in the region had been badly affected by pesticide exposure and residues in the water. However, these possible external costs of pesticide to the environment resulting from misuse of production resources have not yet been considered in rice production in the Mekong Delta agriculture.

In the light of the adverse effects of pesticides, it is vital to know how current use of pesticide endangers farmers' health and labor productivity, or whether the marginal gain from reduced pesticide use surpasses the marginal loss in rice productivity and farmers' benefit. Such information would help in developing policies in the direction of restricting pesticide use.

3.0 OBJECTIVES OF THE STUDY

This study investigated the impacts of pesticide exposure on rice farmers' health in Mekong Delta, Vietnam. The overall objectives were to examine pesticide productivity and estimate the optimal level for profit maximization; determine types of health impairments caused in farmers by pesticide use, and estimate the damage costs due to health impairment brought about by pesticide exposure. From these, recommendations on regulation of pesticide use may be suggested to policymakers.

Some hypotheses in the domain of pesticide exposure and epidemiological issues would be specifically examined and verified as follows: 1) Probabilities of health risk are related to farmers' characteristics and pesticide exposure; 2) Health costs from pesticide exposure substantially raise the cost of paddy production; and 3) Alternative regulatory schemes that reduce pesticide application in rice production would be able to improve social welfare via better health and profitability.

4.0 METHODOLOGY

4.1 Estimation Procedure

The empirical analyses of this study relied on three procedures. Initially, production elasticity and optimal level of pesticides were derived from the yield function model. Then, Logit regressions were done to relate the positive incidence of health ailments to pesticide exposure (Health Risk Logit Regression Model). Next, to quantify the health impairment of farmers with respect to personal characteristics of farmers and their use of pesticides, two sets of dose - response functions were constructed: one using the survey data and the other using coefficients adjusted and transferred from the Philippines (Health Cost Model)

4.2 Pesticide Productivity and Optimal Level for Profit Maximization

4.2.1 Rice yield function

The Cobb-Douglas function was used to relate material inputs to rice yield in the Mekong Delta in order to examine pesticide productivity. This function in Log-linear form is expressed as follows:

$$LnY = Ln\alpha_0 + \alpha_1 Soil + \alpha_2 Mefarm + \alpha_3 Lafarm + \alpha_4 EDU2 + \alpha_5 EDU3 + \beta_1 LnNPK + \beta_2 LnTodose + \beta_3 LnHirLab + \beta_4 LnFarlab$$

where:

LnY = natural logarithm of yield (ton/ha)
LnNPK = natural logarithm of total nitrogen, phosphorus, and potassium fertilizers (kg/ha)
LnTodose = natural logarithm total dosage of all pesticides used (gram a.i./ha)
LnHirlab = natural logarithm of hired labor (mandays/ha)
LnFarlab = natural logarithm of family labor (mandays/ha)
Mefarm = 1 if medium farm (5-10 acres) = 0 if otherwise
Lafarm = 1 if big farm (>10 acres) = 0 if otherwise
Soil = 1 if soil class is category 1 = 0 if otherwise
EDU2 = 1 if farmers get secondary school level = 0 if otherwise
EDU3 = 1 if farmers get high school and upper level = 0 if otherwise

4.2.2 Optimal level of pesticide for profit maximization

To determine the optimal amount of pesticides used, under the assumption of profit maximization behavior, the following relationship was derived:

The marginal physical product (MPP) of pesticides was equated to the ratio of the pesticide and paddy price, that is: MPP = dY/dTodose = Pp/Py.

Thus MPP = β_2 (Y/Todose) = Pp/Py. The optimal amount of pesticides, then, will be: Todose* = (β_2 .Y. Py) / Pp

where:

β_2 = production elasticity of pesticides
MPP = marginal physical product of pesticides
Pp = the unit price of pesticides (VND/gram a.i.)
Py = the farm gate price of the paddy (VND/kg)

4.3 Health Risk Logit Regression Model (Health Risk Model)

A Logit model was used to relate econometrically a set of medical risk indicators to a set of farmer characteristics and to estimate probabilities of health risk due to pesticide exposure. The overall mathematical expression can be presented as:

$$\text{Ln Odds } \left(\frac{P_i}{1-P_i}\right) \text{ (Specific, multiple health impairments)} = \alpha + \beta_1 \text{ (Pesticide exposure)} + \beta_2 \text{ (Farmers' characteristics)}$$

where: *Pi* is the probability of having a specific health impairment and 1-*Pi* is the probability of not having a specific health impairment. To know the probability of a farmer in the survey area suffering from a specific health impairment, the following formula was employed:

$$Pi = \text{Exp.}(\alpha + \beta iXi) / 1 + \text{Exp.}(\alpha + \beta iXi)$$

- The dependent variable was considered as a discrete dependent variable, and the symptoms and epidemiological data were collected to construct this variable.

- The independent variables in the model were defined as follows:

Variables and Notation	Definition
AGE (sample farmer's age)	Years since birth
EDU (farmer' s education)	Years of formal education
HEALTH (a proxy for health and nutrition)	Farmer's weight (kg) by height (meter)
SMOKE (active smokers)	= 1 if smoking regularly; = 0 otherwise
DRINK (alcohol drinking habit)	=1 if drinking regularly; = 0 otherwise
TOCA1 (total dose of categories I & II)	Gram a.i. per hectare
TOCA3 (total dose of categories III & IV)	Gram a.i. per hectare
TODOSE (total dose of pesticides)	Gram a.i. per hectare

4.4 Health Cost Model

Health costs of farmers from pesticide exposure were linked with total pesticide dose, pesticide exposure (the number of times the farmer gets in touch with pesticides), pesticide hazard categories, and "other" personal characteristics. Based on the environmental economics literature on health production function, the following log - linear regression model was assumed in the estimation:

LnHC = f (LnAGE, HEALTH, SMOKE, DRINK, LTODOSE, LINDOSE, LHEDOSE, NA, NA1, NA3, TOCA1, TOCA3, IPM, CLINIC)

In which:

LnHC = Log of health costs of farmers
LnAGE = Log of farmers' age
HEALTH = Farmers' weight by height
SMOKE = Dummy for smoking (0 for nonsmokers, and 1 for smokers)
DRINK = Dummy for drinking alcohol (0 for nondrinkers & 1 for drinkers)
IPM = Dummy for IPM adopter (0 for non-IPM farmers & 1 for IPM farmers)
LTODOSE = Log of total dosage of all pesticides used (gram a.i./ha)
LINSECT = Log of insecticide dose used (gram a.i./ha)
LHERB = Log of herbicide dose used (gram a.i./ha)
LFUNG = Log of fungicide dose used (gram a.i./ha)
TOCA1 = Total dose of categories I & II (gram a.i./ha)
TOCA3 = Total dose of categories III & IV (gram a.i./ha)
NA = Log of number of applications of pesticides/ season
NA1 = Number of times in contacting with TOCA1/ season
NA3 = Number of times in contacting with TOCA3/ season
CLINIC = Dummy for those who had hospital access (0 for those without hospital access)

- Health cost components. In this study, the total cost (in VND) incurred by farmers due to pesticide induced illness was calculated based on the following kinds of costs: opportunity costs of work loss days (assumed to be equal to wage multiplied by the number of days off) and restricted activity days; costs of recuperation (meals, medicines, doctors or hospitals) which were obtained through direct interview with sprayers; and costs of protecting equipment.

- Actual health cost incurred in a single season only and health costs during the last four years (1992-1996) were used in alternative estimation models. The estimated health cost for the population was weighted by percentage of farmers going to the clinic.

- The average medical treatment cost was then added to the estimated heath cost for the ones who did not go to the clinic to get the final estimated health cost of farmers due to pesticide exposure. (The average medical treatment cost is given in the appendix.)

- The total number of times of getting in touch with TOCA1 and TOCA3 was a bit different from the number of applications of pesticides. This was because NA1 and NA3 were defined as the number of times that farmers had contact with a certain kind of pesticide and, therefore, each farmer could be exposed to more than one type of pesticide during one application. This means that the sum of NA1 and NA3 would be at least equal to or larger than the number of applications. This separation was expected to more explicitly reflect the impact of pesticide on farmers' health impairments.

- Coefficients of the health cost function from the Philippines were used to estimate the health cost to farmers in the Mekong Delta and to compare them with current results. Production data and other information on Mekong Delta farmers were used in the transferred model.

4.5 Data Set and Method of Collection

4.5.1 Site selection

A field survey was undertaken by interviewing a sample of individual farmers from six sub-districts in four provinces of the Mekong Delta, including Tien Giang (Nhi My, Cai Lay dist.), Dong Thap (Tan Phu Trung, Chau Thanh dist.), An Giang (Vinh My, Chau Doc dist.; Long Dien B, Cho Moi dist.), and Can Tho (Thanh Xuan, Dong Phuoc, Chau Thanh dist.). These six sites were selected based on various levels of intensive paddy cultivation and pesticide application. In addition, farmers in these study sites were those interviewed in the 1992 dry season for the study on economics of rice production. This enabled the researchers to examine whether the relationship between pesticides and health cost existed in the area. The random sampling method was used to choose farmers for personal interviews at each study site. A total of 180 farmers were interviewed in these six villages (30 farmers for each site). The survey, begun in January 1997 and completed in April 1997, was done in cooperation with officials from the local Extension Centers and Plant Protection Sub-Departments in the Mekong Delta provinces.

4.5.2 Data

Data necessary for this study were mainly derived from two sources: (1) farm household survey in the Mekong Delta and (2) pesticide dose-response functions in relevant countries (i.e., the Philippines). All data were collected and recorded according to a formatted questionnaire which contained the following information: farm inputs and prices; pesticide exposure; farmers' and family characteristics and other variables affecting health; symptoms due to prolonged exposure to pesticides; medical history and expenditures incurred in treating the illness of farmers particularly focused on health impacts caused by pesticide use; farmer's awareness of the change in health conditions due to greater or prolonged pesticide use; farm outputs and prices; and income from the farm and other sources.

Data on production and health problems were recorded by farmers during the 1996/97 winter-spring season with the help of local agricultural officers. Final checking of data was done at the study sites by a research team from the Environmental Economics Unit (EEU), Department of Economics, Vietnam National University at Ho Chi Minh City. Production data in the 1992/93 winter-spring rice season of sample farmers were used for comparison and as references.

5.0 PESTICIDE REGULATION POLICY IN VIETNAM

5.1 Pesticide Regulation Policy

The Plant Protection Department is the authorized agency that designates pesticide application in Vietnam agriculture. The Department has offices at all provinces and districts, establishing a complete national network. It has contributed greatly to agricultural production through its successful operations, especially in the Mekong Delta. Since 1993, many new regulations on plant protection and pesticide use were enacted and actively undertaken throughout the country, including the following:

a) The decree on plant protection and quarantine was promulgated by the National Assembly on February 15, 1993. This decree aims to improve the efficiency of State management in terms of increasing the effectiveness of shielding resources, contributing to better production and to the protection of public health and environment. In terms of plant protection chemicals, some significant points include:

   - The manufacturing, export, import, storage reservation, distribution, and use of all plant protection chemicals will undergo the State's unified management in accordance with regulations. The Government stipulates the build-up, management, and use of a reserve fund for plant protection chemicals at all levels.

   - The Ministry of Agriculture and Rural Development defines and announces the list of pesticides permitted, restricted, and banned from use as well as promulgates the testing of pesticides in the list in each period. Transport and application of plant protection chemicals not in the list are strictly prohibited as well as production and sale of fake and expired chemicals, chemicals of unknown origin and without trade-mark, or chemicals with specifications and qualities inappropriate to registered trade-mark or patents.

   - Any organization/individual with complete requirements for plant protection and quarantine and other conditions as given in the regulations, which has been granted a license by government authorities, will be allowed to produce, export, import, and distribute plant protection chemicals.

   - Safety to the people and the environment during production, storage, and transportation of plant protection chemicals must be ensured.

b) Ordinances on plant protection, plant quarantine, and pesticide management were enacted on November 27, 1993 based on the decree dated February 15, 1993. For pesticide management, the ordinances covered the issues related with pesticide manufacturing, formulation, export, import, allocation, usage, inspection, and testing at the reserve fund for plant protection chemicals.

c) Pesticide registration: the aim of pesticide registration is to ensure the technical efficiency, safety to human beings and environment, and other requirements of the regulation policy. The legislative structure of pesticide registration in Vietnam contains the decree, ordinances and decisions above. The Pesticide Control Center was set up in 1994 to implement the State's functions regarding the management of pesticide for quality, residues on agricultural and forestry products, and testing of new pesticides.

d) The detailed regulations on plant protection and pesticide were published by the Ministry of Agriculture and Rural Development in 1995. Effective 1994/95, most Plant Protection Sub-Departments (PPSD) were no longer responsible for pesticide sales and distribution.

e) The Ministry of Agriculture and Rural Development announced on May 22, 1996 the list of plant protection chemicals allowed, limited, or prohibited from being used.

f) Investment in pest management and production of pesticides: the State encourages domestic and foreign organizations and individuals to invest in many forms of prevention and control of pests as well as to produce plant protection chemicals in Vietnam (extracted from chapter I about general regulations). However, in 1996, MARD recommended that licenses be no longer issued to companies that are either joint ventures or with 100% foreign capital to build factories producing plant protection chemicals.

5.2 Vietnam IPM Program

Vietnam has adopted Integrated Pest Management in rice as an approach to plant protection. This program is still continuing and has helped increased agricultural productivity.

The practice of rice IPM in Vietnam began when Vietnam became a participant in the FAO inter-country rice IPM program in March 1989. It was only in April 1992, however, that Vietnam officially took part in the IPM network. In 1994, a national IPM program for rice was instituted to strengthen the country's capacity to provide more efficient service to rice farmers. At the same time, the IPM network coordinated by the International Rice Research Institute contributed to the Farmer Participatory Research approach so as to directly transfer IPM program to rice farmers (Mai, 1994). The main objective of the program was to increase small-scale farmers' knowledge and help them make better decisions in the pest control of rice production systems.

The IPM program in Vietnam had two training courses: Training of Trainers and Farmers' Field Schools. Other approaches to transfer this technology included plant protection games, IPM seminar, radio, and television which had less significant impact and needs to be adapted and evaluated.

More than 1,350 IPM trainers had undergone Training of Trainers. After this training, this group of IPM trainers conducted Farmers' Field Schools (FFS) in all 53 provinces of Vietnam. Over 7,000 FFSs (25-30 participants for each one) had been organized in 3,000 villages in Vietnam. The IPM trainers served as resource persons for other farmers in their villages. As a result of the FFS and the data from the surveys of farmers' practices in their own fields, farmers participating in the IPM program reduced their pesticide use by approximately 75 percent on the average. They were able also to save on the amount of fertilizers and seeds they used, hence, lowering production costs. More importantly, the IPM farmers gained similar or higher yields than non-IPM farmers.

6.0 PESTICIDE USE IN RICE FARMING

6.1 Types of Pesticides Used by Mekong Delta Rice Farmers

The type and amount of pesticides used in rice crops depended on the pest population and their potential damages to the crop as well as farmers' perception regarding pest management practices. The survey in the 1996/97 Winter-Spring season showed that farmers used 17, 30, and 28, of herbicides, insecticides, and fungicides, respectively (Tables 2, 3, and 4).

Table 2. Types of herbicides used in the Mekong Delta, classified using the WHO category.

Category	Common Name	Trade Name
II	Paraquat	Gramoxone 20 SL
III	Butachlor + Propanil	Cantanil 550 EC
III	2.4 D	Anco 720 EC
III	2.4 D	OK 720 EC
III	2.4 D	2,4 D 720 EC
III	MCPA + Fenxaprop-P-ethyl + 2.4 D	Tiller 50 EC
III	Propanil	Wham 80 DF
III	2.4 D	Vi 2,4 D 80 WP
IV	Metsulfuron Methyl	Ally 20 DF
IV	Butachlor	Batoxim 60 EC
IV	Butachlor	Echo 60 EC
IV	Butachlor	Meco 60 EC
IV	Pyrazosulfuron Ethyl	Sirius 10 WP
IV	Metsulfuron Methyl + Bensulfuron	Sindax 10 WP
IV	Pretilachlor	Sofit 300 EC
IV	Oxadiazon	Ronstar 25 EC
IV	Fenxaprop-P-ethyl	Whip's 7,5 EC

Source: 1997 survey

Table 3. Types of insecticides used in the Mekong Delta, classified using the WHO category.

Chemical Type	**Category**	**Common Name**	**Trade Name**
Organochlorine	II	Edosulfan	Thiodan 30 EC
Organophophate	II	Diazinon	Basudin 50 EC
	II	Fenitrothion	Sumithion 50 EC
	Ia	Methyl parathion	Methyl Parathion 50EC
	Ib	Methamidophos	Filitox 60 SC
	Ib	Methamidophos	Monitor 50 SC
	Ib	-	Azodrin 50 EC
Carbamate	II	Fenobucarb	Bassa 50 EC
	II	Fenobucarb	Bassan 50 EC
	II	Fenobucarb + Phenthoate	Hopsan 75 EC
	Ib	Carbofuran	Furadan 3 G
	Ib	Benfuracarb	Oncol 20 EC, 25 WP
Pytheroid	II	Alpha-cypermethrin	Cyper alpha 5 EC
	II	Deltamethrin	Decis 2,5 EC
	II	Alpha-cypermethrin	Fastac 5 EC
	II	Alpha-cypermethrin	Fastocide 5 EC
	II	Fenvalerate + Dimethoate	Fenbis 25 EC
	II	Lambda-cyhalothrin	Karate 2,5 EC
	II	Alpha-cypermethrin	Sapen alpha 5 EC
	II	Cypermethrin	Sherpa 25 EC
	II	Esfenvalerate	Sumi alpha 5 EC
	II	Alpha-cypermethrin	Vifast 5 EC
	II	Cypermethrin	Visher 25 EC
Others	II	Metaldehide	Deathline Bullet 4G
	II	Cartap	Padan 4 G, 95 WP
	II	Fipronil	Regent 0.3 G, 800 WP
	IV	Buprofezin	Applaud 10 WP
	IV	Etofenprox	Trebon 10 EC

Source: 1997 survey

Table 4. Types of fungicides used in the Mekong Delta, classified using the WHO category.

Category	Common Name	Trade Name
II	Tricyclazole	Beam 75 WP
II	Propiconazole	Tilt 250 EC
III	Iprobenphos	Kitazin 50 EC
III	Copper Oxychloride	Viben - C 50 WP
III	Triadimenol	Bayfolan
III	Isoprothiolane	Fuji – one 40 EC
IV	MAFA	Dinasin 6,5 EC
IV	-	Komix TS 9
IV	Validamycine	Vivadamy 3 EC
IV	Zineb	Zineb 80% WP
IV	Hexacodazole	Anvil 5 SC
IV	Carbendazim	Appencarb super 50 FL
IV	Carbendazim	Bavistin 50 FL
IV	Benomyl	Bemyl 50 WP
IV	Benomyl	Bendazol 50 WP
IV	Benomyl	Benlat C 50 WP
IV	Carbendazim	Cadazim 50 FL
IV	Carbendazim	Carbenzim 50 WP
IV	Captan	Captan 7,5 WP
IV	Zineb + Bordeaux + Benomyl	Copper - B WP 75%
IV	Carbendazim	Derosal 50 SC, 60 WP
IV	Mancozeb	Dithane 2-78 72 WP
IV	Benomyl	Fundazol 50 WP
IV	Thalide + Kasugamycin	Kasai 21,2 WP
IV	Mancozeb	Mancozeb 80 WP
IV	Benomyl	Mimyl 12,5 SP
IV	Pencycuron	Monceren 25 WP
IV	Thiophanate-Methyl	Topsin 50 WP, 70 WP
IV	Iprodione	Rovral 50 WP (10 G)
IV	Validamycine	Validacine 5 WP, 5 EC

Source: 1997 survey

Based on the World Health Organization (WHO) classification of pesticides, farmers used mostly insecticides in categories I and II, which are classified as moderately and extremely hazardous, respectively. In the Organochlorines (OCs) group, although Edosulfan is restricted in Vietnam, it was still used by 3 percent of the farmers in the Mekong Delta. However, as shown in Table 5, there was a significant decrease in the use of restricted insecticides in rice production in the 1996/97 dry season. For instance, the proportion of farmers and the amount of Methyl Parathion applied in the 1996 dry season were far less than those in the 1992 dry season. A comparison of insecticide type used showed that 17 percent of insecticide sprays in Vietnam compared with 20 percent in the Philippines belonged to WHO's category Ia, i.e. extremely hazardous chemicals; most of these sprays were Methyl parathion (Heong, et al., 1994). At present, Organophophates (e.g., Methyl parathion & Methamidophos) and Carbamates (e.g., Carbofuran and Benfuracarb) are restricted by the Ministry of Agricultural and Rural Development but Mekong Delta farmers (4.5%, 19.1%, 3%, and 1%, respectively) continued to use them. This may be partly due to the availability of the stocks of these insecticides after their ban and their relatively cheaper price and wide-spectrum toxicity. There could also be some weakness in the enforcement and control of the use of hazardous chemicals or unavailability of choices for substitution.

Table 5. Trend in pesticide use of rice farmers in the Mekong Delta

Item	**WHO Classification**	**1992/93 Dry Season**		**1996/97 Dry Season**	
		%	**Ave./ha**	**%**	**Ave./ha**
1. Types					
Methyl Parathion	Ia	36	625	4.5	180
Metaphos	Ia	3.3	365	-	-
Azodrin	Ib	26	631	5.6	317.5
Monitor	Ib	26	737	17.4	424
Thiodan	II	8	460	2.8	29.8
Furadan	Ib	10	45.6	2.8	350
2. Quantity(g a.i./ha)			1,786		1,017

Source: 1992 and 1996 dry season surveys.

On the other hand, about 60 percent of paddy farmers used insecticides in the Pytheroids group with diverse types such as Cypermethrin, Deltamethrin, and Alpha-cypermethrin, together with Carbamates like Fenobucarb, which is classified in the moderately hazardous category (II). Compared with the extremely hazardous insecticides, use of the latter categories to some extent could mitigate risks from pesticide exposure to farmers' health. However, their use does not mean that farmers are free from the dangers of poisoning.

Given the current direct seeding techniques in rice farming, using herbicide is almost a must for farmers to eradicate weeds at the very early stage of crop growth. Farmers often use 2,4-D, Butachlor and Fenxappro-P-ethyl to control weeds. In contrast to insecticides, of the 17 types of herbicides listed in Table 2, only one, Gramoxone, belonged to category II. This kind of hazardous herbicides poses potential damage to health. Gramoxone, at only 5ml of active ingredients, can cause death when ingested. Although restricted, it was still in use, thus there were cases of acute poisoning symptoms among rice farmers. However, not more than 2 percent of the farmers used this herbicide. The rest of the herbicides belonged to category III and IV, which the WHO defines as slightly hazardous and unlikely to present acute hazard in normal use, respectively. As mentioned, 2,4-D is one of those that cause many symptoms of disorders for sprayers because of pesticide exposures.

Another big group of pesticides that farmers applied to control rice disease was fungicides (Table 4). About 30 types of fungicides were used in the 1996/97 dry season. The most popular fungicides were Propiconazole, Iprodione, Validamicine, and Zineb. Although fungicides do not cause serious and acute damage to farmers' health, they have been reported to cause some harm to farmers' skin and eyes.

There were other pesticides that did not belong to the groups mentioned above, but were used by nearly 50 percent of the sample farmers. They included Applaud and Trebon which belonged to category IV, which WHO considers as products unlikely to present acute hazard in normal use. They were used by about 10 percent of the farmers.

6.2 Quantity of Pesticide Use

Figure 1 shows that among the pesticides, insecticides were used the most (394 grams a.i. per hectare) followed by herbicides (323 grams a. i. per hectare) and fungicides (300 grams a.i. per hectare) in Mekong Delta. On the average, farmers applied 1,017 grams a.i./ha per crop of pesticides. The amount of pesticides used by the sample farmers decreased by 43 percent compared with the amount they used in the 1992 dry season. A general decrease in the quantity of pesticide use was observed, which could be attributed to the implementation of the IPM program. Farmers tended to use less hazardous but highly effective pesticide types.

Integrated Pest Management as practiced by more than 30 percent of the farmers helped reduce significantly the amount of pesticides applied per unit of area. Pesticide dose used by IPM farmers (883.9 grams/ha) was lower than that applied by non-IPM farmers (1,081 grams/ha). This difference was statistically significant at 0.1 level. Farmers' adoption of the practice of not spraying insecticides in 40 days after sowing could be the main reason for the significant decrease. This result implies that costs of pesticide use and health damages likewise had been mitigated.

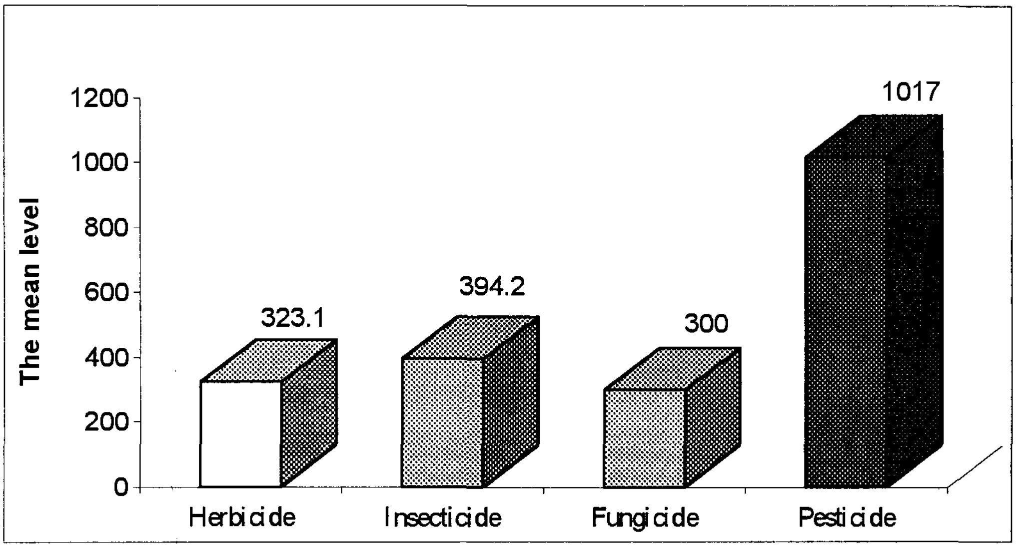

Figure 1. Pesticide dose used in rice farming (a.i. gram/ha).

To visualize better the usage level of pesticides at the study sites, six villages were divided into two groups. Group 1 included the villages of NhiMy, VinhMy, and DongPhuoc; the rest of the villages belonged to group 2. Results showed that this division resulted in very significant results at the 0.01 level with respect to insecticides, fungicides, and herbicides. The pesticide use levels of group 1 were significantly higher than those of group 2. This implies that farmers' health at three villages, namely: NhiMy, VinhMy, and DongPhuoc, was easily impaired by their high level of pesticide application.

Table 6. Pesticide use in the 1996-97 winter-spring rice crop, classified by dose.

Kinds of Pesticide	Group 1	Group 2	t – ratio
Insecticide	503.6	287.2	3.09***
Fungicide	397.3	204.9	3.70***
Total pesticide	1,229.0	806.0	3.97***

Source: 1997 survey

6.3 Frequency of Pesticide Application

The threat to health from exposure to pesticides may also result from frequent contact with pesticides belonging to hazardous categories. In the last few cropping seasons, the average frequency of pesticide application had slightly declined. Farmers decreased their frequency of insecticide application but raised that of herbicide or fungicide spraying due to demand of their rice fields. More than 22 percent of the respondents applied pesticides 3 times for each crop (Figure 2). None of the farmers applied pesticides 10 times or more, unlike in the earlier seasons. This reflected partly the farmers' perception of the efficiency of pesticide use.

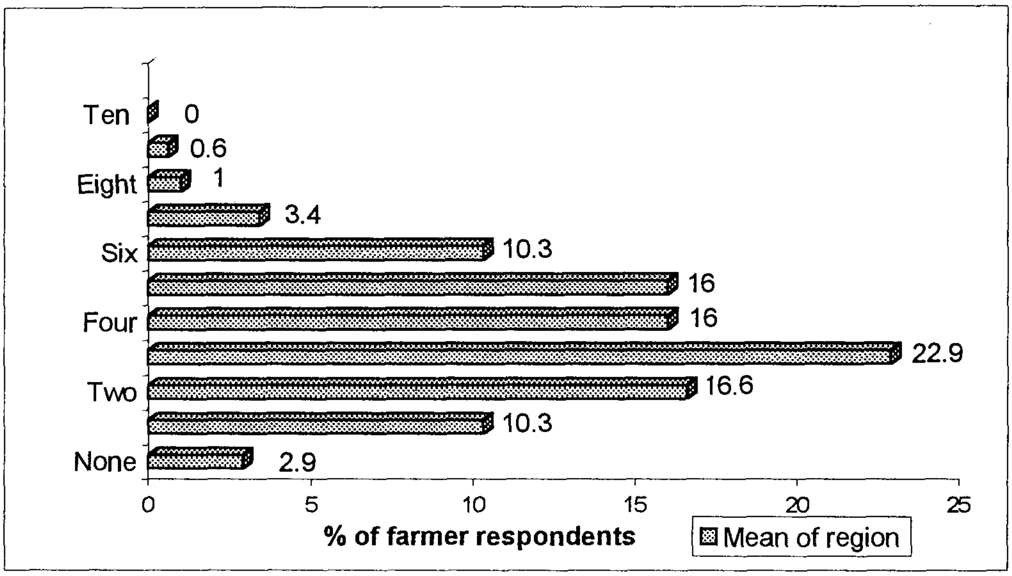

Figure 2. Number of pesticide applications in the 1996-97 dry season.

6.4 Farmers' Behavior and Perception in Pesticide Application

Examining the farmers' behavior and perception helped to understand their current pesticide practice. As shown in Table 7, more than 95 percent of the farmers perceived that long-term application of pesticides affects health.

Table 7. Farmers' perception of effects on health of prolonged pesticide use.

Degree of Effect (% of respondent)	Nhi My	Tan P Trung	Long Dien	Vinh My	Thanh Xuan	Dong Phuoc	Region
No effect	6.7	0.0	16.7	4.0	0.0	0.0	4.6
Very little effect	13.3	20.0	13.3	4.0	27.6	10.0	14.9
Little effect	26.7	30.0	33.3	38.5	20.7	26.6	29.0
Much effect	30.0	23.3	13.3	30.5	31.0	6.7	22.3
Very much effect	20.0	26.7	16.7	11.5	17.3	16.7	18.3
Extremely large effect	3.3	0.0	6.7	11.5	3.4	40.0	10.9

Source: 1997 survey

However, only 33.3 percent of the farmers used protection equipment such as cap, mask, and clothing when spraying. The most common reasons for not using safety equipment were that farmers did not feel comfortable wearing protection equipment (21.8%), they had no money to buy them (17.8%), and using protection clothing was not suitable for the local condition (17.5%) (Table 8). It was also shown that farmers who participated in IPM activities used safety gears more often than non-IPM farmers.

Table 8. Use of protection equipment when spraying pesticides as reported by farmers

User/Non-user (% of respondents)	**Nhi My**	**Tan P Trung**	**Long Dien**	**Vinh My**	**Thanh Xuan**	**Dong Phuoc**	**Region**
Equipment users	46.7	20.0	13.3	24.0	35.5	60.0	33.3
Non-users due to							
No money to buy	0.0	36.7	26.7	16.0	17.2	10.0	17.8
Uncomfortable	20.0	23.3	16.7	56.0	6.9	13.3	21.8
Inappropriate	6.6	6.7	30.0	0.0	0.0	0.0	7.5
Unnecessary	10.0	13.3	6.6	4.0	24.2	10.0	11.6
Other reasons	16.7	0.0	6.7	0.0	17.2	6.7	8.0

Source: 1997 survey

On the other hand, the sources of information which influenced farmers in their application of pesticides were very diverse. About 27.7 percent of the respondents received help from agricultural extension officials about the types and quantity of pesticides that should be applied (Table 9). These often were farmers who followed the IPM program, therefore, had basic knowledge about pests. The rest (72.3%) obtained information from other sources such as experience, television, newspapers, input sellers, radio, etc. A large number of farmers relied on their own experience (26%), on TV advertisement (14.1%), or on material input sellers (11.9%).

Table 9. Information sources of farmers regarding pesticide application.

Information Source	**Nhi My**	**Tan P Trung**	**Long Dien**	**Vinh My**	**Thanh Xuan**	**Dong Phuoc**	**Region**
Other farmers	0.0	3.3	31.0	14.6	0.0	0.0	7.9
Agricultural extension	10.0	40.0	17.2	35.5	33.3	30.0	27.7
Television	6.7	10.0	24.2	14.3	23.4	6.7	14.1
Radio	6.7	6.7	0.0	10.6	16.7	3.3	7.3
Newspaper	0.0	6.7	0.0	0.0	0.0	0.0	1.1
Input sellers	20.0	13.3	3.4	3.6	20.0	10.0	11.9
Experience	36.6	20.0	24.2	21.4	3.3	50.0	26.0
Other sources	20.0	0.0	0.0	0.0	3.3	0.0	4.0

Source: 1997 survey

6.5 Pesticide Application and IPM Program in the Mekong Delta

After IPM activities were introduced in the Mekong Delta by the Plant Protection Department, the IPM farmers accounted for 32.6 percent of the sample farmers in the six study sites. Although the number of farmers (58 over 178 interviewed farmers) applying methods of cultivation associated with IPM program was not yet high enough as expected, the efficiency of the IPM program after five years of its introduction to the farmers was undeniable.

Significant differences between IPM farmers and non-IPM farmers were observed regarding some aspects of pesticide use (Table 10). IPM farmers used lesser amount of pesticides belonging to all categories than non-IPM farmers. Moreover, the number of applications of non-IPM farmers (3.7) was higher than that of IPM farmers (3.5). As a consequence, pesticide efficiency and health ailments due to exposure were different among groups of farmers as presented in the next sections.

Table 10. Some production characteristics of IPM and non-IPM farmers, 1997.

Pesticide Exposure	**IPM**	**Non-IPM**	**T ratio**	**Region**
Category I & II (gram a.i./ha) (CA1)	394.70	457.60	0.88	436.90
Category III & IV (gram a.i./ha) (CA3)	533.88	602.90	0.94	580.10
Average dose of pesticides /ha	883.90	1,081.00	1.93**	1,017.00
N° of applications	3.46	3.67	0.94	3.60
N° of exposure to CA1	2.10	2.70	2.33***	2.50
N° of exposure to CA3	2.80	2.60	0.60	2.65

Source: 1997 survey; **, ***: statistical significance at 0.05 and 0.01, respectively

7.0 PESTICIDE AND RICE PRODUCTIVITY

Pesticides are commonly expected to contribute to increased rice yields by minimizing damages caused by pests. However, a continuous increase in pesticide application in excess of the necessary level will cause spillover effects on both economic return and ecological environment, especially on farmers' health. Therefore, it is essential for paddy farmers to keep the pesticide amount at the optimal level in order to maximize profit and reduce costs to environment in which cost to farmers' health is a serious concern.

7.1 Estimated Contribution of Production Factors to Rice Yield

Regarding technical efficiency of production scales, the results in Table 11 showed that large farms were more efficient productivity-wise than smaller farms. Phuong (1997), using enterprise budgeting to examine the benefits of rice production, also obtained the same conclusion. However, some previous studies in rice production (Dung, 1994) revealed that economic efficiency was higher in small farms (< 9 acres). Hired and family labors contributed positively and significantly to rice yields. The influence of family labors to rice yield was similar to that of hired labors, with estimated coefficients of 0.102 and 0.099, respectively. The IPM program contributed significantly to an increase in rice yields. This supports the results presented in the previous sections. The coefficients of education variables also revealed that rice yield of higher-educated farmers was higher than that of lower-educated farmers. Soil class was also positively and significantly related to rice yield. Rice yield per hectare of soil class 1 was higher than that of other classes according to the value of this coefficient.

Table 11. Multiple regression analysis of yield function in the Mekong Delta, 1997.

Dependent Variable: Log[a] of yield		
Explanatory Variable	**Estimated Coefficient**	**Standard Error**
Constant	0.328	0.296
Log of NPK	0.086*	0.052
Log of hired labor	0.099***	0.032
Log of family labor	0.102***	0.028
Log of pesticides	0.035***	0.013
Dummy for medium farms	0.031	0.032
Dummy for large farms	0.087**	0.034
Dummy for soil class	0.054*	0.029
IPM	0.047*	0.027
Dummy for secondary school	0.017	0.029
Dummy for high school & the upper	0.023	0.033
R squared	0.261	
F – value	5.86***	

*, **, *** : statistically significant at 0.10, 0.05, and 0.01 respectively.

[a] Denotes natural logarithm

Most noticeable in the yield function is that agro-chemicals had significant effects on yield. Yield (in natural logarithm form) increases by 0.86 percent corresponding to a 10 percent rise in the amount of fertilizers used (in natural logarithm form). Similarly, a 10 percent increase in total dose of pesticides will contribute to a micro-increase of 0.346 percent in yield. However, economic returns should be considered before investing further amounts of fertilizers and pesticides. This raises the question of what optimal levels of these chemicals should be applied so as to get maximum profit, given current farm-gate prices.

Given the average yield (6,440 kg/ha) and prices of rice (1,283 VND/kg) and pesticide (385 VND/gram of active ingredient), the optimal level of pesticide that farmers should have applied in the 1996 winter-spring rice season for profit maximization is:

Optimal application of pesticide* = (0.0346 x 6,440 x 1,283)/385 = 742.6 grams

However, the mean level of pesticide used in the Mekong Delta was 1,017 grams a.i. per hectare. As such, farmers overused pesticides by 274.4 grams a.i. per hectare. In other words, farmers lost 105,644 VND (274.4 x 385) per hectare because of an uneconomical investment of pesticides in their rice farming. Profit maximization is attained at the optimal level, therefore any increase in pesticide use higher than the optimal level is really not a rational investment. Moreover, in the trend of overusing pesticide, environmental problems are inevitably generated.

7.2 Efficiency in Rice Production of the IPM Program

In economic terms, production performances of IPM farmers were much better than those of non-IPM farmers as presented in Table 12 and Figure 3. It was hypothesized that the IPM program contributes significantly to a decrease in costs rather than an increase in yield. However, the current data revealed that rice yield of IPM farmers was also higher by 400 kg per hectare than that of non-IPM farmers.

Moreover, pesticide costs of IPM farmers were lower than those of non-IPM farmers. Thus, the total production cost of the former was larger than that of the latter though insignificantly different from zero. As a consequence, the benefit cost ratio (0.94) of IPM farmers was higher than that of non-IPM farmers (0.79). The most significant point is that the IPM program successfully helped farmers to decrease health costs from pesticide exposure. Health cost of IPM farmers was lower than that of non-IPM farmers at 0.1 level of confidence. In this sense, net benefits of IPM and non-IPM farmers were 4,069,300 (VND) and 3,356,400 (VND), respectively.

Table 12. Rice production economics in the Mekong Delta, 1996/97 dry season.

Item	IPM Farmer	Non-IPM Farmer	t – ratio	1996/97 Dry Season	1992/93 Dry Season
Yield (kg/ha)	6,700	6,300	3.13***	6,440	6,163
Pesticide cost (VND)	318,600	327,500	0.78	324,600	249,400
Labor cost (VND)	1,763,000	1,614,000	-1.42**	1,662,000	1,029,000
Fertilizer cost (VND)	1,028,000	983,700	-1.01	998,000	724,500
Seed cost (VND)	352,500	406,300	1.86***	388,900	234,300
Other cost (VND)	1,245,000	1,219,000	-0.40	1,227,000	771,800
Total cost (VND)[a]	4,707,000	4,550,000	-1.08	4,601,000	3,009,000
Return (VND)	8,865,000	7,998,000	-3.14***	8,279,000	5,983,000
Benefit (VND)	4,158,000	3.447,000	-2.67**	3,667,000	2,973,000
Return to pesticides	21.6	18.9	-0.94	19.73	27.07
Return to fertilizers	5.30	4.60	-2.04**	4.86	6.49
Return to labors	3.70	3.40	-1.03	3.50	4.84
Cost/kg of rice (VND)	710	737	1.06	728.00	500.00
Benefit/Cost ratio	0.94	0.79	-2.1**	0.84	0.89
Benefit/Return ratio	0.46	0.41	-1.91**	0.43	0.47
Estimated health cost[b]	88,700	90,600	0.38	89,310.00	-
Net benefit (VND)	4,069,300	3,356,400	-2.61***	3,577,690	-

Source: 1997 survey, [a] health cost not included, [b] Estimated from model 1

Note: Economic indicators in the table are defined as follows:

Return = Yield in kg x price per kg
Benefit = Return - total cost
Total cost = Costs of pesticides, fertilizers, seeds + costs of labors + other costs
Return to pesticides = (Return - all costs other than pesticides)/total pesticide cost
Return to fertilizers = (Return - all costs other than fertilizers)/total fertilizer cost
Return to labor = (Return-all costs other than labor)/total labor cost
Net benefit = Benefit: Health Cost Avoided

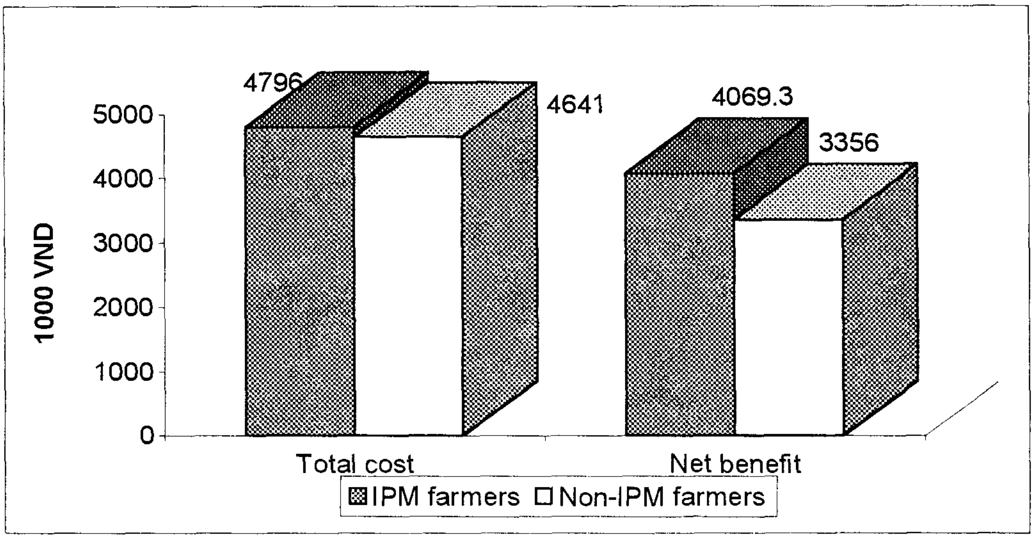

Figure 3. Cost and benefit of Mekong Delta farmers.

8.0 FARMERS' HEALTH PROFILE AND HEALTH COST DUE TO PESTICIDE EXPOSURE

8.1 Farmers' Health Impairments from Pesticide Exposures

Results of the 1996-97 winter-spring crop survey (Table 13) revealed that 69.7 percent of the farmers were quite sure of the acute poisoning symptoms from pesticide exposure. Meanwhile, only 1.4 percent of the respondents had no opinion on the effects of pesticide exposure. Investigating differences in health status via an interview with direct sprayers showed evidence of eye, skin, cardiovascular, and neurological effects. The farmers' interview revealed that each person can get simultaneously more than one acute poisoning symptom. Among the poisoning symptoms caused by exposure, the impact of chemical pesticides on the eyes and neurological system (headache, dizzy) and dermal effects were the most discernible to farmers (Table 14).

Table 13. Farmers' perception of pesticide poisoning symptoms (% of respondents who got symptoms).

Farmers' Opinion	Nhi My	Tan P Trung	Long Dien	Vinh My	Thanh Xuan	Dong Phuoc	Region
No opinion	0.0	6.70	00.0	00.0	0.0	0.0	1.4
Maybe	0.0	3.30	10.7	20.0	0.0	0.0	6.3
Sure	11.8	10.0	3.5	4.0	0.0	5.5	5.8
Rather sure	70.6	76.7	67.9	64.0	91.7	38.9	69.7
Completely sure	17.6	3.30	17.9	12.0	8.3	55.6	16.8

Source: 1997 survey

Table 14. Percentage of respondents who experienced pesticide poisoning.

Symptom	Nhi My	Tan P Trung	Long Dien	Vinh My	Thanh Xuan	Dong Phuoc	Region
Eye irritation	3.3	20.0	10.0	20.0	10.3	10.0	12.1
Headache	14.3	70.0	44.3	52.0	34.5	23.3	41.8
Dizzy	6.7	36.7	33.3	48.0	49.3	46.7	26.2
Vomit	0.0	3.30	6.7	24.0	10.3	3.3	7.5
Diarrhea	0.0	3.30	0.0	22.0	0.0	0.0	2.3
Fever	0.0	10.0	10.0	16.0	17.3	13.3	1.9
Convulsion	0.0	0.0	3.3	22.0	0.0	0.0	2.3
Shortage of breath	10.0	13.30	10.0	24.0	13.8	16.7	14.4
Heart trouble	3.3	20.00	20.0	52.0	3.4	3.3	16.1
Skin irritation	10.0	26.70	43.3	73.1	17.2	23.3	31.4
Cough	0.0	3.3	0.0	15.4	0.0	0.0	2.9
Others (fatigue, trouble sleeping)	36.7	50.00	53.3	53.8	34.5	33.3	43.4

Source: 1997 survey

8.1.1 Eye effects

Table 15 presents the determinants of farmers' health impairments. In the five senses of the human being, the eye provides the most help to people in terms of perception. Eye irritation decreases sight and other unexpected symptoms. Farmers generally paid little attention to bad effects of pesticide on the eyes and other organs. Incidence of eye irritation increased significantly with drinking habit and exposure to herbicides and fungicides (TOCA3). The ratio of weight by height carried a negative sign as expected on eye abnormalities. In addition, a number of contacts with pesticides of categories I & II (NA1) contributed significantly to an increase in eye irritation while the number of herbicide exposure (NA3) did not have both the expected positive sign and statistical significance.

8.1.2 Neurological effects

The incidence of headache was significantly associated with drinking habit, age, and nutritional status; drinking habit influenced most strongly the incidence of farmers' headache. Farmers with drinking habit experienced this symptom more easily than non-drinking farmers. The smoking habit had the expected positive sign though not significant. Herbicide and fungicide (TOCA3) had a significantly positive effect on this symptom; the effect of insecticides (TOCA1) was also positive but not significant. In fact, a 1 percent rise in TOCA3 contributed slightly to a probability of 0.00073 percent increase (in log of the odds) in farmers' headache after spraying.

Farmers at the sample mean with respect to age and health status who did not drink alcohol had a 22 percent probability of experiencing headache. Meanwhile, farmers who frequently drank alcohol had a 50 percent probability of getting headache. In addition, a doubling of total doses of herbicides and fungicides from the mean level would lead to an increase of headache symptom by 60 percent. Furthermore, the probability of neurological problems doubled with respect to change in farmers' age.

Table 15. Logit regression on health impairments of rice farmers.

Variable	Eye Effect	Headache	Skin Effect	Multiple Ailments	Multiple Ailments 96'
Constant	-1.74* (0.98)	0.33 (1.93)	-0.37 (0.68)	1.17 (0.85)	-4.23** (1.71)
Age	0.0033 (0.0079)	0.025* (0.014)	-0.012*** (0.0058)	- 0.001 (0.0063)	0.03** (0.014)
Smoking		0.13 (0.44)		0.035 (0.19)	0.18 (0.42)
Drinking	0.73*** (0.23)	1.25*** (0.43)	0.30** (0.17)	0.31* (0.176)	1.2*** (0.43)
Weight/height	-0.056** (0.026)	-0.095* (0.05)	-0.036*** (0.018)	-0.038* (0.023)	0.032 (0.041)
TOCA1	0.000033 (0.00018)	0.00033 (0.00045)	-0.000092 (0.00015)	0.00009 (0.0002)	0.00035 (0.00046)
TOCA3	0.001*** (0.00018)	0.00073* (0.0004)	0.0011*** (0.00015)	0.0014*** (0.00025)	0.00084* (0.00045)
NA1	0.195*** (0.061)	0.12 (0.12)	0.15*** (0.047)	0.25*** (0.058)	0.11 (0.13)
NA3	-0.058 (0.057)	-0.185 (0.11)	0.086** (0.042)	0.12** (0.057)	-0.044 (0.11)
Log-likelihood	-443.2	-101.53	-681.34	-545.94	-101.57
Chi-square	63.15***	23.1***	138.53***	144.56***	23.2***

*, **, ***: statistically significant at 0.10, 0.05, and 0.01 respectively.
Figures in parentheses are standard errors.

8.1.3 Skin effects

Skin problems were popularly discerned in rice farmers who were often exposed to pesticides. The Logit regression estimates indicated that the incidence of skin problems was positively and significantly related to the dose of herbicides and fungicides. In contrast to theoretical expectation, the coefficient of total doses of categories I & II carried a negative but insignificant sign. This reflected the dominant effect of the number of contacts with insecticides on the skin. As expected, the general health status with a negative sign was related significantly to skin effects.

Farmers at the sample average for age and nutritional status who did not apply any herbicide had a 35 percent probability of skin problems. The probability of skin irritation rises to 56 percent for farmers at the mean level of three times of contact with herbicides and 60 percent for farmers with four times of herbicide contacts.

8.2 Incidence of Multiple Health Impairments

The analysis presented above considers separately the impact of pesticide on specific illness. Nevertheless, farmers experiencing pesticide exposures over time may be confronted with several health impairments at the same time. The regression results showed that the incidence of multiple health impairments was positively and significantly related to drinking habits, total doses of herbicides and fungicides, as well as to the number of contacts with insecticides, herbicides, and fungicides. NA1 impacted more strongly on farmers' health impairments than NA3. At the sample mean age and health status, farmers who did not apply any herbicides or fungicides had a

45 percent probability of experiencing two or more poisonings at the same time. The average level of three herbicide contacts increases this probability by 85 percent. An additional dose of herbicide from the mean level shots up to 92 percent the probability of having two or more health impairments.

For the 1996 winter-spring rice crop, multiple health ailments due to pesticide exposures showed weak relations. The regressed results revealed that the incidence of multiple health impairments was significantly and positively related to age, drinking, and total dose of herbicides. Farmers will be impaired by a probability of 0.00084 percent (in log of the odds) when the total dose of herbicides is increased by one percent. Smoking habits and the number of contacts with insecticides had the expected though not significant signs. Health status and the number of contact with herbicides had signs contrary to theoretical expectation; they were not also significantly different from zero.

In estimating the models of farmers' health impairments, the important conclusions can be summarized as follows:

- Insecticides affect negatively and significantly farmers' health via the number of contacts rather than total doses used in farmers' rice fields.

- Herbicides and fungicides impact substantially on farmers' health ailments with respect to their quantities.

- The smoking habit is not significant in all models while the drinking habit influences positively and significantly farmers' health impairments, especially relating strongly to headache symptom.

- Age only impacts positively on models of headache symptom and the 1996 multiple ailments while the general health status contributes significantly to farmers' health ailments in models, except for the model on 1996 multiple ailments.

8.3 Farmers' Health Cost from Exposure to Pesticides

8.3.1 Estimation of health costs to farmers from pesticide exposure in the 1996-1997 winter-spring rice season

Estimating farmers health costs is a function of pesticide exposure via total dose of active ingredients used by farmers and other characteristics of farmers such as health status (proxy by weight over height ratio), age, and dummy variables indicating whether the individual smokes cigarettes, drinks alcohol or not. The sample did not include any farmer who went to the hospital (clinic) for cure of the poisonous symptoms in this rice season. Therefore, the dummy variable CLINIC was excluded from models 1 and 2.

Using data from the winter-spring rice crop, Table 16 shows that the total dose of pesticides significantly affected health costs. Costs increased by 0.385 percent for every 1 percent increase in total dose. Health costs were also affected significantly by insecticide and herbicide doses. A 1 percent rise in insecticide dose would lead to a 0.075 percent rise in health costs while costs to farmers' health would increase 0.144 percent for each 1 percent increase in herbicide dose.

Table 16. Valuation of health costs of rice farmers in the 1996/97 winter-spring season.

Dependent Variable: Log[a] of Health Cost				
Independent Variable	**Model 1**		**Model 2**	
Constant	0.65	(0.20)	2.7	(1.83)
Log of age	1.41***	(0.41)	1.24***	(0.4)
Weight by height	-0.026	(0.027)	- 0.02	(0.026)
Dummy for smoking	0.02	(0.27)	0.12	(0.27)
Dummy for drinking	0.72***	(0.25)	0.62***	(0.25)
Log of total dose	0.385***	(0.138)		
Log of insecticide dose			0.075**	(0.04)
Log of herbicide dose			0.144***	(0.039)
R^2	0.1537		0.1925	
Regression F-value	5.52***		6***	
Estimated health cost (VND)	44,310		46,390	
Final health cost	89,310		91,390	

*, **, ***: Statistical significance at 0.10, 0.05, and 0.01 levels, respectively;
[a] Denotes natural logarithm; Figures in parentheses are standard errors.

Drinking habit contributed significantly to a rise in farmers' health costs in both models. Meanwhile, the coefficient of weight by height ratio, though insignificant, had a negative sign as expected. This implies that nutritional status was also related to farmers' health impairments but not very clearly. Smoking habit carried a positive sign but not statistically different from zero. Lastly, age increased significantly farmers' health costs. The older the farmers become, the higher the health costs.

Health costs per farmer associated with variables as described in Table 16 averaged 44,310 VND for the winter-spring rice crop while health costs of model 2 reached 46,390 VND. These costs reflected only those that farmers would spend in recovering their health at home. If the opportunity costs of medical treatment for curing poisonous symptoms were added, the final estimated health costs to rice farmers in model 1 and 2 would be 89,310 VND and 91,390 VND, respectively.

8.3.2 Estimation of health costs to Mekong Delta farmers due to exposure to pesticide use in the last four years

Together with data collected from the winter-spring rice crop, this study also recorded farmers' acute poisoning symptoms from pesticide exposure as well as costs spent on their cure from 1992 to 1996. Eight equations were used: model 3 and model 4 associated with variables in the model of Rola and Pingali (1993); and model 5 similar to those in the model built by Antle and Pingali (1994) so as to make a comparison between the Vietnam case and the Philippine case. The dummy variable (CLINIC) was included in these models since a number of farmers (3.3 percent of sample farmers) accessed local clinics for poisoning treatment during the last four years. Its inclusion would show whether there exists a higher cost to those who went to clinics than those who did not. Results are presented in Tables 17 and 18.

a. Effects of farmers' personal characteristics

Farmers' age (except in equations 4 & 8) impacted significantly on health costs at a statistical level of 0.05. This implies that the older the farmers, the weaker their resistance to disease. In most equations, weight by height ratio had a negative though not significant influence on health costs.

Conversely, the better the farmers' health status, the lower the ailment induced by pesticide due to stronger resistance to illness. The coefficient of drinking alcohol variable though carrying a positive sign was not significant whereas drinking habit increased significantly health costs in the winter-spring rice season. Compared with Rola's model, the coefficient of drinking habit though significant had a negative sign. She argued that some measurement deficiencies might influence this result; or some farmers might have stopped drinking because they already had a disease or ailment.

Table 17. Determinants of health costs induced by prolonged pesticide exposure.

Dependent Variable: Log^{a} of Health Cost					
Explanatory Variable	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Constant	7.3*** (1.09)	9.2*** (1.03)	8.84*** (1.06)	7.3*** (1.1)	8.5*** (1.1)
Age	0.43** (0.22)	0.32 (0.23)	0.39** (0.23)	0.43** (0.22)	0.43** (0.23)
Dummy for going to clinics	0.9*** (0.32)	0.94*** (0.33)	0.68** (0.32)	0.83*** (0.32)	0.75** (0.33)
Weight/height	-0.022 (0.015)	- 0.017 (0.015)	- 0.015 (0.015)	-0.025* (0.015)	- 0.023 (0.016)
Dummy for smoking	0.21 (0.15)	0.25* (0.15)	0.24 (0.15)	0.22 (0.15)	0.21 (0.15)
Dummy for drinking	0.17 (0.14)	0.103 (0.145)	0.12 (0.14)	0.15 (0.14)	0.1 (0.14)
Log of insecticide dose		0.066*** (0.026)			
Log of herbicide dose		0.072*** (0.022)			
Log of total dose	0.34*** (0.078)			0.28*** (0.086)	
N^{O} of application				0.33** (0.2)	0.37** (0.22)
N^{O} of CA1 exposure			0.4*** (0.12)		
N^{O} of CA3 exposure			0.18 (0.13)		
Total dose of CA1					0.03 (0.03)
Total dose of CA3					0.076** (0.037)
R^2	0.2065	0.1849	0.1840	0.2222	0.1887
Regression F-value	6.11***	4.54***	4.51***	5.67***	4.01***
Not go to clinics (VND)	47,970	47,660	47,670	48,140	47,610
Go to clinics (VND)	120,600	122,300	118,600	119,800	119,300
Average health costs	93,901	93,659	93,544	94,039	93,510

*, **, *** = Statistically significant at 0.10, 0.05, and 0.01, respectively
Figures in parentheses are standard errors

b. Effects of pesticide dose

Considering the impact of total quantity of prolonged use of pesticide on farmers' health costs, estimates showed that a 1 percent increase in total dose of pesticides contributed significantly to a rise of 0.34 percent (model 3) or 0.28 percent (model 6) in health cost. More concretely, if total active ingredients of pesticides were classified by insecticide, herbicide, and fungicide doses, it can be seen that insecticides and herbicides significantly increased farmers' health costs while the coefficient of fungicide variable in model 8, though insignificant, had a positive sign. This implies that fungicide doses also affected positively the health costs but maybe its share in total pesticides was smaller than those of insecticides and herbicides, thus the effect was seemingly indistinct. Farmers' health impairments are also influenced by hazardous categories. Total dose of CA3 affected significantly the dependent variable.

Table 18. Estimated health cost distribution for farmers in the Mekong Delta.

Dependent Variable: Log[a] of Health Cost			
Explanatory Variable	**Model 8**	**Model 9**	**Model 10**
Constant	9.2***	7.3***	8.5***
Age	0.32	0.4**	0.43**
Dummy for going to clinics	0.94***	0.82**	0.75**
Weight/height	- 0.016	- 0.02	- 0.023
Dummy for smoking	0.25*	0.23	0.2
Dummy for drinking	0.095	0.15	0.1
Log of insecticide dose	0.067***		
Log of herbicide dose	0.073***		
Log of fungicide dose	0.0067		
Dummy for IPM	0.056	0.046	0.006
Log of total dose		0.24**	
N^{O} of application			0.38**
N^{O} of CA1 exposure		0.21	
N^{O} of CA3 exposure		0.09	
Total dose of CA1			0.0326
Total dose of CA3			0.0763**
R^2	0.1863	0.2213	0.1887
Regression F-value	3.51***	4.36***	3.54***
Not go to clinics	47,710	48,230	47,610
Go to clinics	121,700	119,900	119,300
Average health costs	93,678	94,129	93,510

*, **, *** = Statistically significant at 0.10, 0.05, and 0.01 level, respectively.
[a] Denotes natural logarithm

c. Effects of frequency of pesticide application

The number of applications significantly increased health costs. Effects on health degradation of the number of contacts with category I and II (NA1) pesticide as well as the number of contacts with category III or IV (NA3) were different. NA1 was significantly and positively related to the level of health impairments and hence health costs, with estimated elasticity of 0.4 (model 5). Meanwhile, NA3 carried a positive sign but was not statistically significant in models 5 and 9. This could be explained by the dominant effect of total dose of CA3 in total active ingredients of pesticides rather than NA3 on health costs. NA1 also affected significantly farmers' health costs more than CA1 in model 5.

The positive and significant coefficient of the dummy variable for going to clinic showed that farmers who went to clinics spent more money than those who did not. It is because the former farmers must pay medical costs (basic treatment costs) at clinics, therefore, their estimated health cost was higher than the latter. Since health services through insurance program were not yet popular in the Mekong Delta, rice farmers went to clinics only when their diseases became serious.

By adding basic treatment costs to estimated health costs of farmers who did not go to clinics, the average health costs of sample farmers after being weighted by percent of farmers who went/did not go to clinics ranged from 93,510 VND to 94,129 VND following models presented above. Nevertheless, a point is noticeable here that health costs were measured by poisonous symptoms associated with four years of exposure to pesticide use whereas the pesticide application data used to estimate the models in the above table were only for a singe season. Therefore, the results of the regression models may underestimate the importance of the relationship between pesticide use and health ailments.

8.3.3 Estimation of farmers' health costs based on the Philippine model

In the Philippines' case, farmers' health cost computations were based on medical tests conducted. An assessment of each farmer-respondent's ailments and their seriousness was provided through these tests. The doctor performed a complete physical examination on every farmer. Cholinesterase determination was carried out by the medical technologist; chest X-rays and electrocardiograms were handled by the X-ray technician. Thus, treatment costs (including medication and physicians' fees) plus the opportunity cost of farmers' time lost in recuperation formed a measure of the health cost per farmer. Rola and Pingali (1993) performed health cost models with regression results as follows:

$$\text{Ln(Health Cost)} = 1.33 + 1.82^{**}\ \text{Ln(age)} - 0.05\ \text{Ratio of weight by height} + 1.1^{***}\ \text{Smoking dummy} - 0.77^{*}\ \text{Drinking dummy} + 0.62^{**}\ \text{Ln(total dose)}$$

These estimated coefficients were adopted in the Vietnam case, typically to the Mekong Delta rice-growing region where farmers had similar exposure to the same chemical pesticides as well as similar environment or bio-physical conditions with rice farmers in the Philippines. Then, real data of sample farmers were used to estimate health costs from prolonged exposure to pesticides. The transferred model predicted the farmers' average health costs to be 90,336 VND per rice crop when they get chronic symptoms from pesticide exposure (Table 19). The average health cost estimated by the transferred model was nearly the same as that estimated in models 1 and 3 (basic treatment costs of poisonous symptoms included). Hence, the transferred model would be helpful also for future estimation of pesticide induced health cost to rice farmers.

Table 19. Comparison of estimated health cost due to pesticide exposure.

Item	**Model 1**	**Model 3**	**Philippine Model**
	Dry season 1996/97	**Four years 1992/96**	
Constant	0.65	7.3	1.33
Log of age	1.41	0.43	1.82
Weight by height	-0.026	-0.022	-0.05
Smoking	0.02	0.21	1.1
Drinking	0.72	0.17	-0.77
Dummy for going to clinics	-	0.9	-
Log of total dose	0.385	0.34	0.62
Estimated health cost	44,310	93,901	90,336
Final health cost	89,310	93,901	90,336

Source: Calculated

9.0 CONSEQUENCES OF TAX POLICY TO RESTRICT PESTICIDE USE

In this section, elasticities of health cost from model 1 and yield production model were used to investigate the impacts on health and productivity of restricting pesticide use by imposing a tax on pesticide price. Furthermore, a change in pesticide price has impacts also on the demand for complementary inputs such as labor and fertilizer through pesticide cross-price elasticities. Hence, the own-price elasticity of pesticide and its cross-price elasticities with respect to labor and fertilizer available from Phuong's study (1997), which used the same data set as this study, were employed as important components of the model. Eleven policy alternatives of tax imposed on current pesticide market price were simulated. This tax on pesticide price could be also called "health tax" to reduce the cost to farmers' health.

Table 20 presents necessary information on material inputs and rice output for computation. Price elasticities of demand for variable inputs derived from the translog cost function showed that labor and fertilizers were complementary factors to pesticide use in rice production. Pesticide own-price elasticity at current prices was estimated at 0.8. The absolute value of this elasticity was smaller than that of the Philippine case (0.9 to 1.0). The output-constant factor demand elasticities for insecticides and herbicides derived from the rice Cobb-Douglas cost function were between -0.9 and -1.0 (Antle and Pingali 1994). As such, farmers in the Mekong Delta did not show high response to the change in pesticide price as the Philippines farmers did.

Table 20. Some economic indicators used to analyze tax policy on pesticide use.

Economic Indicator	**Pesticide(g)**	**Labor (day)**	**Fertilizer (kg)**	**Output (kg)**
Mean level/ha	1,017	96.29	180	6,440
Price/unit (VND)	385	17,000	5,400	1,283
Yield elasticity	0.030	0.1	0.086	-
Health cost elasticity	0.385	-	-	-
Pest. Own-price elasticity	-0.8	-	-	-
Pest. Cross-price elasticity	-	-0.053	-0.038	-

When pesticide price increases by 1 percent, its quantity decreases by 0.8 percent and leads to a reduction in quantities of labor and fertilizer by 0.053 percent and 0.038 percent, respectively. Consequently, productivity will be inevitably reduced with respect to multiple decreases of pesticide, labor, and fertilizer amount per hectare. Total productivity loss will be likewise equal to the sum of yield loss caused by reduction of pesticide, labor, and fertilizer. Farmers will save a certain expense for a decrease in these inputs and health costs.

Simulation results in Figure 4 revealed that the "health tax" reduces inputs and yield. If a 10 percent of tax is imposed on current pesticide price, this would reduce yield by 30.53 rice kg per hectare equivalent to a return loss of 39,130 VND. Similarly, a 20 percent increase in current pesticide price would reduce rice yield by 62.79 kg per hectare or 80,596 VND. It is also easy to see that the higher the tax, the larger the total yield loss and hence the greater the total return loss.

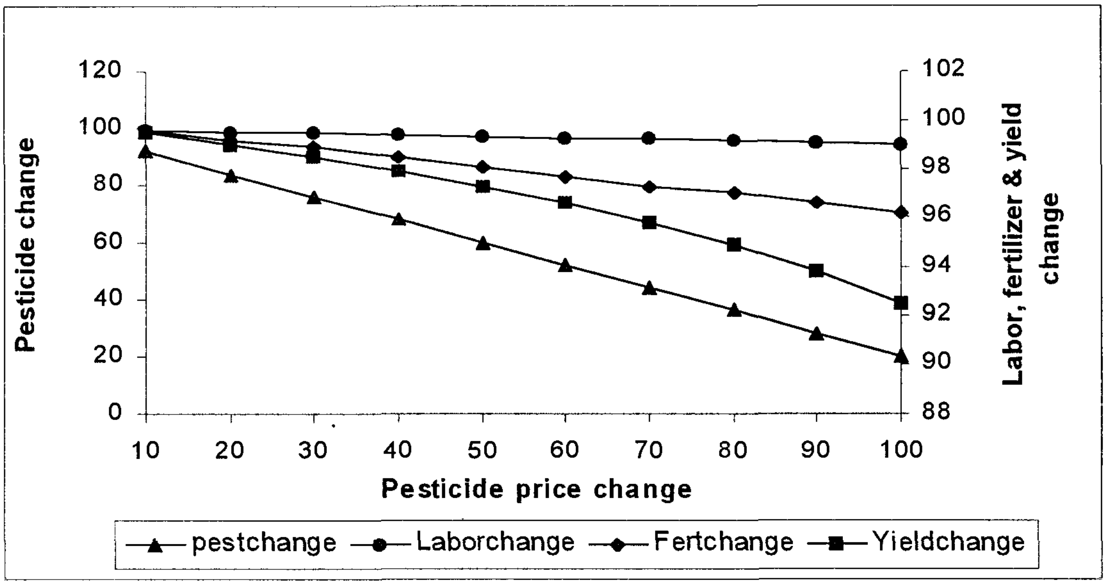

Figure 4. Impacts of pesticide policy on input factors and yield (%).

Table 21 presents the consequences of the health tax to farmers' benefit. When a health tax of 10 percent is put on current pesticide prices, farmers' health cost would be reduced by 4,597 VND. Additionally, farmers would gain 46,826 VND because of savings from pesticide, labor, and fertilizer expenditures. As such, total benefit and net benefit to farmers would be 51,423 VND and 12,292 VND, respectively. Thus, at the farm level, net benefit continues to increase as pesticide health tax increases. It is also noted that government would receive an amount of 36,022 VND with this tax level.

Table 21. Consequences of "health tax" alternatives to rice farmers' benefit (VND).

Rise in Price	**Input Savings**			**Tax**	**Health Cost Savings**	**Total Benefit**	**Farmer's Net Benefit**
	Pesticide	**Labor**	**Fertilizer**				
10%	34,456	8,676	3,694	36,022	4,597	51,423	12,292
20%	75,177	17,351	7,387	65,780	9,344	109,259	28,662
30%	122,162	26,027	11,081	89,272	14,259	173,529	48,681
33.4%	**139,564**	**29,497**	**12,558**	**95,833**	**15,973**	**197,592**	**56,176**
40%	175,412	34,703	14,774	106,500	19,368	244,257	71,775
50%	234,927	43,379	18,468	117,464	24,702	321,476	97,161
60%	300,706	52,054	22,162	122,162	30,304	405,226	123,713
70%	372,750	60,730	25,855	120,596	36,232	495,567	149,750
80%	451,059	69,406	29,549	112,765	42,571	592,585	172,571
90%	535,634	78,082	33,242	98,669	49,454	696,412	187,446
100%	626,472	86,757	36,936	78,309	57,108	807,273	184,828

Source: Simulated from 1997 survey data

Notes:

Pesticide savings = the reduced quantity x new price with respect to an increase in tax
Labor and fertilizer savings = reduced quantities x their current prices
Tax = the quantity of pesticides used x an increase in pesticide price
Total benefit to farmers = input savings + health cost savings
Net benefit to farmers = total benefit - return loss due to loss in productivity

As mentioned in the pesticide use profile, farmers overused pesticide by 274.4 grams per hectare. To eliminate the excessive amount of pesticides, a tax level of 33.4 percent should be imposed on current pesticide price. This would decrease rice yields by 110.22 kg, equivalent to 141,416 VND. But in return, benefits derived from input savings and reduction in health cost would amount to 197,592 VND. Thus, the net benefit to farmers would be 56,176 VND. Finally, an estimated amount of 95,833 VND per hectare would go to the government based on a tax level of 33.4 percent. Overall, in the short-run, such a tax policy would restrict the use of pesticides, which often cause environmental pollution, and farmers' health impairments.

10.0 RECOMMENDATIONS & CONCLUSION

10.1 Policy Recommendations

The Pesticide Control Agency and Plant Protection Department should tightly control and monitor the registration of all kinds of pesticides in terms of their hazardous level in normal use. In addition, government authorities should organize large-scale campaigns to enforce the law and seize banned or restricted pesticide types which still remain in some places. Local traders violating laws on purpose should be heavily fined. The Department of Plant Protection at the provincial and district levels should strictly monitor the kinds of pesticide sold at retail shops.

It is necessary to equip periodically retailers with basic knowledge about the hazards and application of new pesticides in rice farming. It should be ensured that these retailers can read and understand clearly label instructions. In addition to the government's efforts, pesticide companies should conduct workshops to introduce new pesticides into markets in order to provide more information to retailers about the new kinds of pesticides. As a result, sellers can help farmers to use pesticides safely and efficiently, especially those who have no access to IPM training programs. Furthermore, the knowledge of sellers at villages and in districts should be periodically checked.

Enhancing farmers' perception about the health consequences of pesticide exposures and the use of protection equipment during spraying is crucial. The challenge is not lack of money to buy the equipment, but the feelings of discomfort and inconvenience that the farmers have. Therefore, research and development of appropriate protection gear, especially boots and mask, are worth investing in. Because more than 90 percent of the farmer-respondents were willing to use protection equipment if freely provided, the government may decide to use part of the health tax collection to provide free protection equipment to farmers. In addition, the government should encourage pesticide companies to distribute one of these protection equipment to rice farmers rather than promotional items such as cap, handbag, which are not useful in protecting farmers' from pesticide exposures during spaying.

The Integrated Pest Management program is a most promising and efficient policy, hence, the government should give it high priority. IPM should be diffused more widely, even at remote villages in the Mekong Delta. More information on the long-term health cost of pesticide exposure should be enclosed in training packages. In addition, knowledge of nutritional balance through IPM program is also important. A consequence of nitrogen fertilizer misuse is the high population of brown plant hopper (BPH) and other pests. Therefore, misuse of fertilizers results in overuse of pesticides in rice farming.

The net gain to farmers of the tax on pesticides surpasses expected loss in productivity. Such a policy is feasible to reduce the cost to environment and increase production efficiency. Given the current prices of inputs and paddy, a 33.4 percent increase may be imposed on price so that farmers would reduce their pesticide use level (about 27%) to the optimal level for profit maximization.

10.2 Conclusion

Mekong Delta, the biggest rice growing area in southern Vietnam, contributes significantly to the national economic prosperity in terms of food procurement and security for the nation, including producing rice surplus for export. However, environmental problems cannot be isolated from economic concerns. Incorrect pesticide use results not merely in actual yield loss but also in health and environmental damages such as destroying rice-fish culture, killing useful animals, causing air and water pollution. On the farmers' health aspect, when farmers have to take working days off because of pesticide induced ailments, rice yields would not be obtained at the expected rate. Therefore, the problem of farmers' health is an important concern for policymakers when looking at the economic efficiency of rice production.

Until now, costs of environmental problems and farmers' health impairments have not yet been included in the total cost of rice production in the agricultural sector. These opportunity costs contribute significantly to a decrease in rice farmers' profits. Other things being constant, farmers' health costs decreased profits of the winter-spring rice production by about 90,000 VND per hectare. Among the problems is farmers' resistance to wearing appropriate protection gear when handling pesticides. In the long-term, serious degradation of farmers' health would be inevitably induced. Campaigns raising public awareness of pesticide side effects, IPM program, and pesticide tax are promising and workable policies in the future.

Findings from their study hoped to contribute significantly to improving farmers' health as well as raising productivity in paddy production in the Mekong Delta. Valuable information on the negative effects of long-term pesticide use on farmers' health could be drawn from the study. It must be noted here that an inherent shortcoming in the health cost model from the Philippines was discovered in this study. In the Philippine model, pesticide exposures (quantity and frequency) were calculated for a single season only. Hence, estimated health cost may be underestimated. Finally, productivity and health impacts of direct exposure to pesticides were the focus of this study. Further investigations should be done for spillover effects of pesticides.

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APPENDIX

Table A1. Averages and ranges of the variables used to estimate the health impairment equations, Mekong Delta, 1996.

Variable	**Mean and Range of Sample Farmers**
Age (years since birth)	46 (17 - 74)
Weight by height (kg/m)	32.35 (23.20 - 45.40)
Total dose of category I & II (TOCA1)	437 (0 - 2092)
Total dose of category III & IV (TOCA3)	580 (0 - 3429)
Number of contacts with TOCA1	2.5 (0 - 8)
Number of contacts with TOCA3	2.65 (0 - 7)

Source: 1997 survey

Table A2. Local medical examination and acute treatment costs (VND).

Item	**Cardiovascular**	**Skin Effects**	**Neurological Effects**
Examination fee	5,000	5,000	5,000
Basic medical tests (Blood, Urine, EKG tests)	15,000 - 30,000	15,000 - 30,000	15,000 - 30,000
Medicines	5,000 - 50,000	5,000 - 25,000	5,000 - 50,000
Fluid infusion	8,000	-	8,000
Stay in hospital (one day)	5,000	-	5,000
Average cost	53,000	40,000	53,000

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