A Case Study of Pesticide Subsidies and Integrated Pest Control*

J.R. DeShazo and Theodore Panayotou
Harvard Institute for International Development

I. Introduction

It was October of 1986 in the Asian country of Riceland. Planes were spraying pesticides overhead as Mr. Shang, a Riceland agricultural official, explained to the Director of NEDA, the National Planning Agency, "We have miles and miles of rice fields burned out by the stem borer. It looks like a war zone in the rice fields. If we don't stop the pest we could lose a hundred thousand tons of rice this season alone."

"The Prime Minister is just in time then," the Director replied. "He has scheduled several meetings on the pest outbreak with the FAO and NEDA this coming week. As one of the senior officials, I would like you to analyze this crisis at the first meeting," the Director ordered Mr. Shang. "A new pest control strategy, called Integrated Pest Control, has been proposed by the FAO. It may be the answer to our prayers."

Since the 1970s, NEDA, the National Planning Agency which directs the Ministries of Agriculture, Health and Environment, had sought to achieve self-sufficiency by increasing Riceland's rice production. With the aid of enormous government subsidies for pesticides, fertilizers, water and rice itself, rice farmers increased production dramatically. Mysteriously, however, the stem borer and other pests also began to increase. These outbreaks threatened to reverse gains in crop yield, to bankrupt thousands of farmers, and to force the government to import huge quantities of rice.

Mysteriously, the stem borer and other pests began to increase.

**All events, people, and places described herein are fictious.*

Research partially supported by the Asia Bureau of the United States Agency for International Development.

There is a method called Integrated Pest Control that does not rely exclusively upon pesticides.

II. The First Meeting: "What Went Wrong?"

"We are gathered here to pool our expertise and prevent a national disaster," began Mr. Shang at the first meeting. "Dr. Choy, an entomologist from our National Agricultural University will begin our exploration of this crisis with his findings."

"Gentlemen, field tests have shown us that pesticides, when used in large amounts, lead to outbreaks of the stem borer," began Dr. Choy. "Large quantities of pesticides kill the indigenous predators of the stem borer while the eggs of the stem borer, hidden under the rice leaves, survive. The young stem borers emerge with their natural enemies dead and devour the rice shoots. What puzzles me is why our farmers are using more pesticides than necessary," questioned Dr. Choy.

"To the contrary, Doctor, I think our farmers are not using **enough** pesticides," said Mr. Shang. "As an agricultural official, I can tell you our extension agents try constantly to get farmers to use more pesticides. Farmers do not use enough pesticides even though we subsidize them."

Dr. Sung, an economist, motioned to speak. "Dr. Choy, I can provide an answer to your puzzle, but I am afraid it contradicts Mr. Shang's beliefs. Our government has increasingly subsidized pesticides for over a decade. The reason farmers are overusing pesticides is because they are virtually free. As a result, pesticide use has exploded in the last ten years." Dr. Sung continued, "We thought, if a little is good, more must be better.

Dr. Choy responded, "But Dr. Sung, that is the folly of linear thinking. Our research shows that when high quantities are used, pesticides reduce yields. More is not necessarily better. What we are seeing is that the benefits of growth from pesticides can have enormous future costs. I think you have solved the mystery, Dr. Sung. Pesticide subsidies could explain the current disaster," concluded Dr. Choy.

"But how can we control pests without pesticides?" responded Mr. Shang. "Our whole approach to self-sufficiency in rice depends on pesticide subsidies."

Dr. Sung explained, "There is a method called Integrated Pest Control that does not rely exclusively upon pesticides. It is a common-sense method that farmers have used for centuries. Unfortunately, only a few developing countries have tried it."

"I have never of heard of Integrated Pest Control and it sounds risky," said Mr. Shang. "Pesticides have always worked for us before."

"With all due respect Mr. Shang, based on what Dr. Sung has said, pesticides are not working for us now. Without decisive action we are certain to lose this season's crop," said Dr. Choy. "I suggest that we approach the Prime Minister with the Integrated Pest Control proposal."

In an innovative move, the Prime Minister of Riceland signed a decree on November 6, 1986, banning 57 pesticides and beginning the Integrated Pest Control (IPC) program. His decree is presented in Figure 1. The key to the program's success lay in understanding past mistakes and finding a strategy that would achieve the optimal use of pesticides. In the meetings that followed these officials attempted achieve these goals within the framework of IPC.

Figure 1
Prime Ministerial Instruction

1. Pesticides are only to be used when other methods of pest control have proven ineffective, specifically when the pest population exceeds the economic threshold.
2. The type of pesticides utilized and their application methods must take into account the maintenance of natural enemy populations.
3. Pesticides which might cause pest resurgence, resistance or other damaging side-effects are therefore illegal and forbidden.

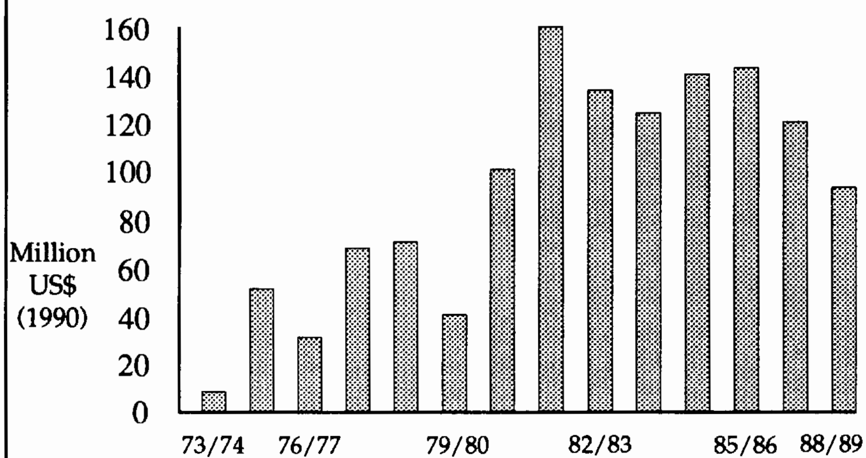
Source: Riceland National IPC Program (1991).

III. The History of Government Policy

"For years Riceland was the number one importer of rice in the world," Mr. Shang explained to the gathered officials later that week. "To improve our food security, we have sought to increase rice production since independence. Self-sufficiency in rice would not only save Riceland foreign exchange, but boost the incomes of the fifty percent of our labor force employed in agriculture. The Green Revolution brought Riceland higher yielding rice varieties which required more water, fertilizer and pesticides, but made self-sufficiency possible. To achieve this goal the government began a program of subsidies for pesticides, water, fertilizer and even rice itself.

Farmers then began to view pesticides as a kind of 'medicine or vitamin' that their plants needed to grow.

Figure 2
Pesticide Subsidies for Rice in Riceland



"The conventional wisdom," Mr. Shang continued, "behind government subsidies was, 'If using a little pesticide produces small improvements in yields, even larger-scale use of pesticide must produce bigger improvements in yields.' This conventional wisdom was conveyed to the farmers by government extension agents. Farmers then began to view pesticides as a kind of 'medicine or vitamin' that their plants needed.

"These subsidies took four forms, as presented in Figure 3. First, some subsidies were **direct and explicit.** This entailed defraying the cost of pesticides imported or sold directly to farmers. This type of subsidy increased farmers' demand for pesticides by lowering prices. This shift in demand for pesticides is presented in Figure 4. As the price of pesticides decreased from P_0 to P_1 due to the increase in subsidies, the quantity of pesticides demanded by farmers increased from Q_0 to Q_1. As a result of the increased demand, the government had to pay not only the amount (P0,A,B,P1) in subsidies at Q_1, but also the amount (A,B,C,D) as represented by the shaded area on the graph in Figure 4.

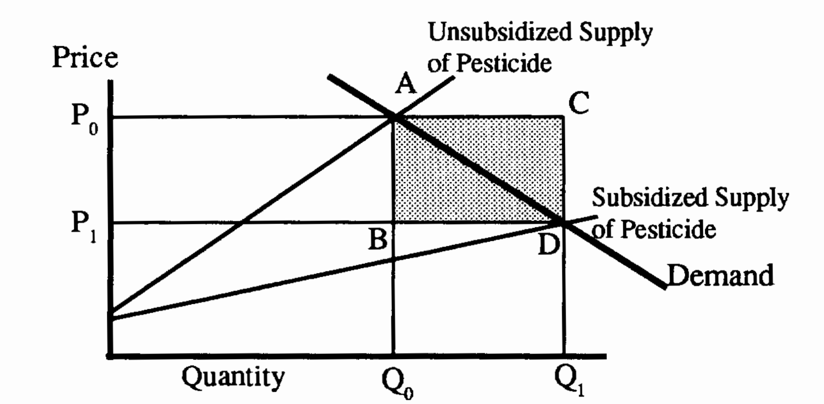
Figure 3
Types of Subsidies

	Explicit	Implicit
Direct	Government sells pesticides Government refunds pesticide companies' cost Pesticides on a credit basis in a package of inputs	Preferential rates for: • Import and local taxes • Import credits • Exchange rate differentials Tolerance of externalities
Indirect	Outbreak budget: • Government sprays • Farmer Sprays	Assumed crop losses: • Definition of a loss • Compilation of loss data • Lack of pest definition • Poor statistics

Source: Adapted from Waibel (1990).

"Second, **indirect and explicit** subsidies took the form of emergency government intervention through spraying or distribution of free pesticides during pest outbreaks. Third, **direct and implicit** subsidies were applied when government policies favored pesticides over other products with lower tax and exchange rates. Fourth, **indirect and implicit** subsidies to pesticides occurred when the government funded the spread of ill-informed ideas about the benefits of pesticides. Extension agents often incorrectly blamed pests for crop losses and exaggerated the benefits of pesticides, thereby increasing demand.

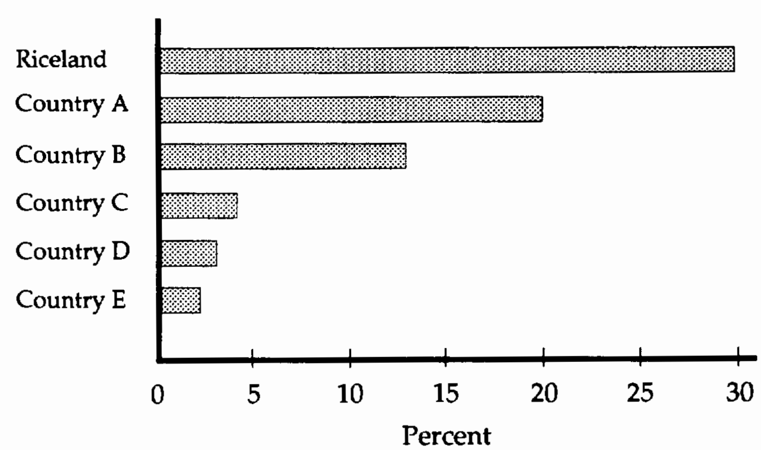
Figure 4
Demand and Supply of Subsidized Pesticides



"The pesticide problem began during severe stem borer outbreaks between 1980 and 1983. The government assumed that the problem was one of insufficient use of pesticides. By the early 1980s, the government was spending over $110 million per year on explicit pesticide subsidies. This increased spending resulted in less and less pest control. Yet the conventional wisdom prevailed: 'We must use more pesticides!' Farmers, paying only 25 to 35 percent of actual cost in the 1980s, were dousing their crops with pesticides as though they were free and highly beneficial."

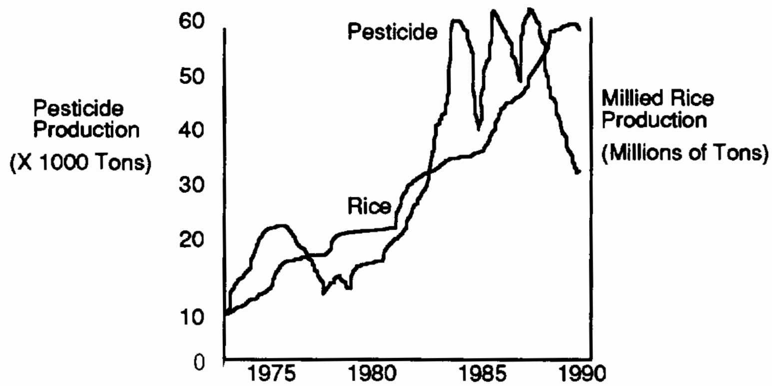
"One result of subsidization was that Riceland used more pesticides than any other country in Asia. Figure 5 reveals that only Country A and Country B even came close. Second, these policies led to the development in Riceland of a growing pesticide industry. The presence of foreign pesticide companies increased the spending of scarce foreign exchange while generating unprecedented environmental pollution. Third, even the vibrant economy of Riceland was hurt by increasing subsidization: $1.5 billion was spent on subsidies over ten years. The more pesticides were subsidized, the more pesticides were used and the more the government had to spend on subsidies.

Figure 5
Pesticide Use Increase by Country, 1980



"Nonetheless, a central goal of Riceland's five-year plan of 1980 was to achieve self-sufficiency in rice production by 1985. NEDA, therefore, increased its pesticide subsidization to $120 million and set the price of rice well above world prices — which itself encouraged increased use of pesticides. Fertilizer, water and rice subsidies led to an increase in rice production, as shown in Figure 6.

Figure 6
Pesticide Use and Rice Production, Riceland



It's like putting oil on a fire — the more pesticides we sprayed, the worse the outbreaks became.

"Slowly, however, evidence began to emerge that excessive pesticide use was causing a decline in rice production. Dr. Choy's work is an example of this research. Initially, government officials, like myself, disbelieved this evidence — with unfortunate consequences," said Mr. Shang.

"Notice in Figure 6 the three surges of pesticide use in the mid-1980s. NEDA, distrustful of the farmers and very near its goal of self-sufficiency in rice, began aerial spraying of pesticides over important growing areas. In line with previous policies, NEDA again increased its subsidies. As you all know, by late 1985 seventy percent of the Western Province's rice crop was threatened by the biggest stem borer outbreak in history. Similarly, rice fields elsewhere were close to devastation. And this, gentlemen, is why we are here today," Mr. Shang concluded.

IV. The Ecological Disaster

"It's like putting oil on a fire — the more pesticides we sprayed, the worse the outbreaks became," said Dr. Choy, the entomologist. "The policy of subsidizing pesticide use actually caused the outbreaks of the stem borer. In many cases, this policy ultimately lowered crop yields while at the same time bankrupting the government. The overuse of pesticides also led to illness and occasional death among rural citizens who misused the pesticides or consumed contaminated food or water.

"The essential problem," Dr. Choy continued, "was that neither the farmers nor the government understood the complex ecological relationships at work in the rice field. For those of you not familiar with the pest, the stem borer is an insect which sucks the juice from young rice shoots. The high-yielding rice varieties of the Green Revolution that we use are especially vulnerable to the stem borer. If not controlled, one female stem

The essential problem was that neither the farmers nor the government understood the complex ecological relationships at work in the rice field.

borer can produce sufficient offspring to destroy two hectares of rice in each growing season.

"We must remember that nature has its own way of controlling pests. Just as the rabbit that ravishes our gardens is prey to the fox, the stem borer which devours our rice crop is prey to spiders and predatory insects. It was not the pesticides that kept the stem borer under control, but these natural predators that feed upon the stem borer. When pesticide prices fell due to government subsidies, farmers used so much pesticide that virtually all of the natural predators were killed. The pesticides, however, did not kill the eggs of the stem borer which are securely nested under the rice leaves. The young stem borers would emerge from their eggs, with all the spiders and predatory insects dead, to feast upon the rice shoots. The reasons for pest outbreaks are presented in Figure 7."

Figure 7
Major Causes for the Outbreaks of the Stem Borer (SB)

1. Susceptibility of genetically altered rice varieties to the SB.
2. SB's increasing tolerance to pesticides due to pesticide overuse.
3. The destruction of the natural predators of the SB due to pesticide overuse.

"This created the boom-bust cycle of the stem borer plagues of the 1970s. The rice would be doused with pesticides. The insect predators of the stem borer would be killed. Thereafter, the young stem borers would emerge from the safety of their eggs and destroy the rice crop. Very slowly the spider and insect predators would return, but only after the damage was done and our crops lost. In addition, the constant exposure of the stem borer to a broad spectrum of pesticides allowed it to adapt and become immune to them.

"The amazing thing about the prey-predator relationship is that it stays in balance if left alone. The stem borer provides food for its predators and as the number of stem borers grows so does the number of its predators. When pesticides kill the natural predators not only does the stem borer population explode, but secondary pests that normally do not appear become a serious threat to the rice plants. By destroying this natural balance between predator and prey we were shooting ourselves in the foot, if you will allow me the expression.

"Pesticide subsidies not only decreased crop yields and increased government debt, they also poisoned our fresh and coastal water," continued Dr. Choy. "Nearly every river, lake and pond in Western Province contained toxic concentrations of pesticides in the late 1980s. This not only poisons those who drink, bath and cook with this water, but also destroys aquatic habitats and fish populations. And we are poorer for the loss of this biological diversity.

"What is even worse is that 30 percent of the vegetables tested (cabbages and mustard greens) greatly exceeded the acceptable levels of pesticide residue. People are poisoned as an indirect consequence of these subsidies. In 1983, before pesticide use reached its peak, the Directorate of Health and Hygiene reported that 168 people were severely poisoned by pesticides — nearly 100 of them died. And all of this was paid for by the tax payers."

V. Integrated Pest Control: The Proposed Solution

"Integrated Pest Control will allow us to achieve both the ecological and economical best use of pesticides," said Dr. Sung, the economist. "The abuse of pesticides has made Riceland the ideal candidate for IPC programs: Riceland has 1) boom-bust cycles of stem borer outbreaks, 2) secondary pest infestation, and 3) the risk of chronic and acute poisoning from pesticides.

"The truth is that pesticide subsidies are neither environmentally nor financially sustainable. We have thrown away vast amounts of foreign exchange and spent billions of taxpayers' dollars on direct pesticide subsidies alone. And the indirect cost in our crop, environmental, and human losses runs into the hundreds of millions of dollars.

The folly of linear thinking: if a little is good, more may not be better.

"IPC replaces the exclusive use of chemical pesticides with biologic, genetic and cultural pest control tactics. Specifically, the IPC pest control strategy requires: 1) the conservation of natural predators, 2) the development of stem borer-resistant rice varieties, 3) careful planting patterns and crop rotation, and 4) the use of a narrow spectrum of pesticides in a manner that targets specific pests. To encourage the selective and need-driven use of pesticides, prices should reflect their true cost — subsidies must be removed.

"An IPC program is based on three major activities. First, research is conducted to determine how to best combat the primary pest and preserve its natural predators. Second, IPC must develop farm-level methodologies so that farmers can learn and apply IPC techniques that are appropriate for their field conditions. Third, IPC must develop a data base and human

Current benefits can have enormous future costs.

resources at the local, regional, and national level so that farmers can be taught how to respond to new threats in a timely manner. Developing these three capabilities requires resources and commitment.

"The effectiveness of IPC across Asia is shown by the improved yields in areas where IPC is used, as presented in Table 1. In other Asian countries experience with IPC has shown that the prerequisites of a successful program are: 1) continued field studies — despite resource constraints, 2) a long-term commitment by both host countries and donors, and 3) an effective extension service for farmers."

Table 1
Comparison of IPM and Non-IPM Rice Yields in Asian Countries

Country	IMP	Non-IMP	Period	N	T-Value*
Country H	3,822	3,340	1989-91	42	7.1
Country B	6,202	5,593	1989-90	6	9.0
Counrty C	4,777	4,452	1986-90	18	4.1
Riceland	6,031	5,921	1987-90	131	2.4
Country D	5,154	5,033	1981-90	91	2.1
Country A	3,695	3,044	1986-89	31	7.9
Country G	3,044	4,094	1990-91	117	9.5
Average	**4,905**	**4,650**	**1981-91**	**444**	**10.8**

* Significant at the 5 percent level.

VI. The Riceland Experience with IPC

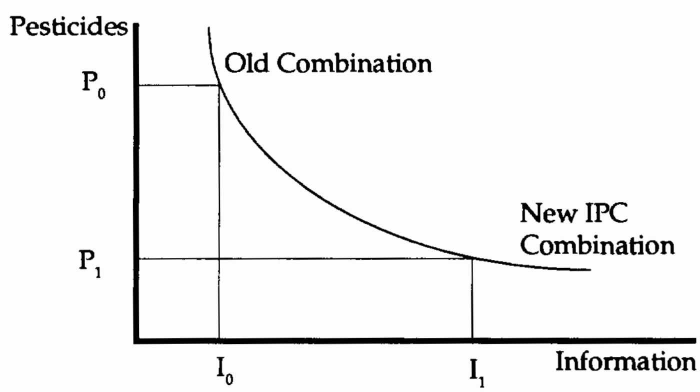
On November 6, 1986, the Prime Minister of Riceland signed a decree initiating the IPC program. The first objective of this reform process was to remove the root cause of the stem borer outbreaks. Therefore, the Prime Minister banned 57 pesticides and decreased subsidies for the remaining pesticides. (NEDA increased the price for unhusked rice to lessen the impact of lower subsidies for poor farmers.) Government subsidies fell from P.s 6.7 trillion in late 1986 to P.s 2 trillion a year later. Although only a few pesticides were permitted, a subsidy of 40 percent remained. In 1989, the Prime Minister finally eliminated all pesticide subsidies.

The second objective of the reform process was implementing the IPC program. This required NEDA, with the help of the FAO, to develop the appropriate pest control technologies for Riceland and then disseminate the information to the rice farmers. Critical research on the stem borer and appropriate agricultural practices was provided by the FAO, IRRI and University of North Carolina at Chapel Hill (UND). Research on the life cycle of various pests, the optimal mix of inputs, crop rotation, and weeding, and monitoring techniques began on test plots in the six major rice growing provinces. In addition, there was complementary research on genetic engineering and pesticides.

The general strategy of IPC is to encourage farmers to use less pesticides and more information. The first information farmers needed to know was the optimal timing and mix of irrigation, weeding, fertilization, crop rotation, and other cultivation practices that would allow natural predators to control pests. Farmers could combine different amounts of pesticides and information in their management techniques. The trade-off between these two is presented in Figure 8, which shows the mix of information and pesticide use under the old policy (P_0/I_0 : low information, high pesticide use) and then under the IPC program (P_1/I_1: high information, low pesticide use).

Externality cost of pesticides should be taxed, not subsidized.

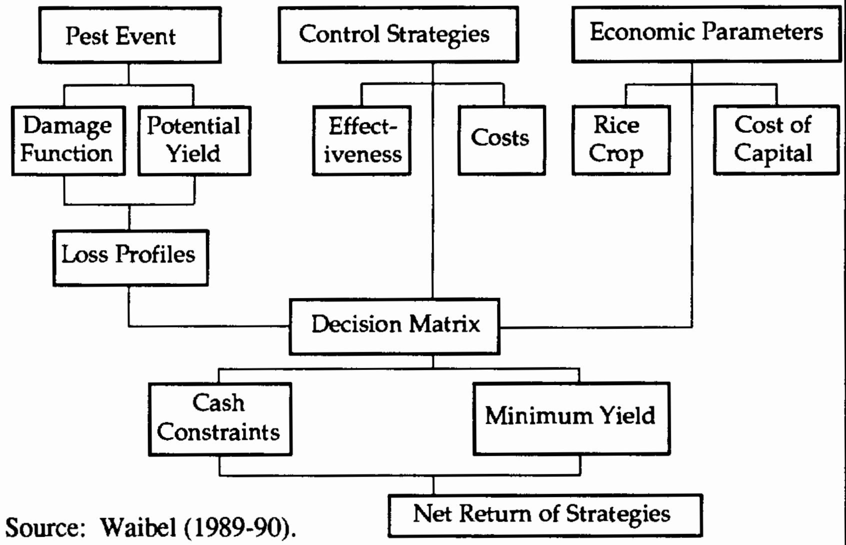
Figure 8
Rice Iso-Production Curve



Source: Adapted from Waibel (1989).

The second skill that farmers needed was the ability to identify when pests were truly a threat to crop yield and when the danger was negligible. Years of misinformation by extension agents made the need for re-education of farmers essential. Armed with this information individual farmers could determine the economic threshold for pesticide application — that is, when the economic gains produced by pesticides exceed the economic and ecological costs. This calculation was missing from past extension work. Figure 8 presents the mix of factors that IPC requires. Rigorous farmer training is critical if farmers are to effectively interpret and manage these factors.

Figure 9
Decision Matrix for Determining the Economic Threshold



Source: Waibel (1989-90).

Dissemination of the IPC techniques occurred not only through direct training but also through publications such as *Helpful Insects, Spiders and Pathogens — Friends of the Rice Farmer*, of which 20,000 copies were distributed in 1987. This was followed by the distribution of posters showing the key enemies of the stem borer.

This information campaign was reinforced by a massive education program supervised by NEDA and supported by the FAO and other international agencies. The University of Myoto established extension and also degree programs: training began in 1989. Over the next three years some 40 master's degrees were given to IPC specialists, while 1,000 Pest Observers, 2,000 Field Extension Workers, and 100,000 farmers received IPC training.

The key to the IPC extension effort is the organization of farmers, pest Observers and Field Extension Workers into autonomous decision- making groups. Some farmers belong to surveillance groups which are supported by both a Pest Observer and Field Extension Workers. They are supplied with state-of-the-art information by IPC specialists. In contrast with earlier centralized government programs, IPC relies on decentralized teams of farmers to assess and respond to local field conditions. This bottom-up organization is the key to preventing major outbreaks and recognizing subtle shifts in the economic threshold for pesticide use.

Since the IPC program began, Riceland has enjoyed record levels of rice production, and yields have increased from 6.1 tons to 7.4 tons per hectare. Virtually no rice has been imported. Pest outbreaks have been controlled and the use of pesticides has dropped from 4.1 to 1.7 applications per season. And, fields have 75 percent fewer stem borers.

Riceland learned a number of conceptual lessons as a result of the IPC program. Conventional wisdom has been reformulated. Specifically, Riceland learned: 1) the folly of linear thinking — if a small amount of pesticide is good, more may not be better, 2) current benefits from pesticides can have enormous future costs, 3) the external cost of pesticides both on-site (killing stem borer predators) and off-site (destroying biological diversity and threatening public health) should be taxed not subsidized, 4) pesticide subsidies are a tax on the efficient use of inputs, information, and proper cropping patterns, 5) IPC's labor and information requirements fit the resource endowments of Riceland, and 6) good economics is good ecology and vice versa.

VII. A Benefit-Cost Assessment of IPC in Riceland

IPC's labor and information requirements fit with Riceland's resource endowment.

The benefit-cost framework used to assess the IPC program is set out in Table 2 (following page). A projection of the main areas in which costs and benefits of the program are expected to occur through 2007 is presented below. The benefits of the program will be considered at both the farm and national level. This will be followed by a consideration of program costs.

A. Benefits of the IPC Program

Farm Level Benefits

1) Reduced Expenditures on Pesticides. A study of 2,000 farmers in 1991 showed that IPC-trained farmers significantly reduced expenditures on pesticides in all six of the major rice-growing provinces, allowing the conservation of insect predators. (Riceland National IPC Program, 1991.) The study showed that farm-level savings was independent of land-holding status and farm size — farmers across the socioeconomic spectrum adopted and benefited from the IPC program. See Figure 10 (following page) for a comparison of pesticide use before and after IPC training.

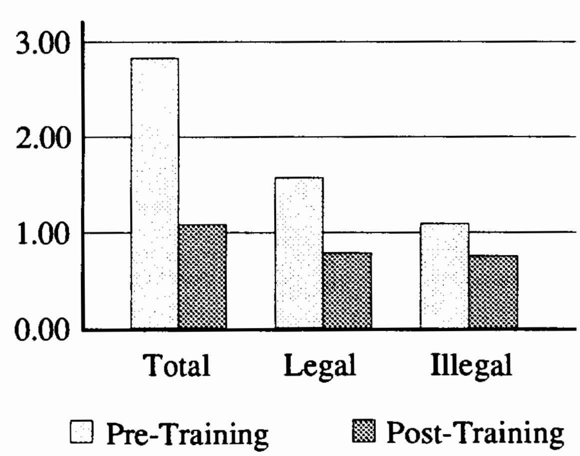
Table 2
Benefits and Costs of IPM

	Farm Level	National Level
Benefit	Reduced expenditure on pesticides.	Reduced risk of major pest outbreak.
	Increased crop yield.	Savings/earnings of foreign exchange.
	Decreased risk of local pest outbreak	Conservation of rice varieties.
	Reduced health risk.	Reduced environmental threats:
	Reduced environmental threats to:	Non-point source pollution
	Local water bodies	Waste from pesticide production
	Fisheries	
	Local food sources	
Cost	Direct project costs	
	Opportunity costs of training(value of farmer's time).	
	Opportunity cost of IPM practices.	

Subsidies for pesticides are a tax on IPC: on weeding, efficient use of inputs, crop rotation, etc.

2) Increased Yield and Reduced Uncertainty. Comparisons of crop cuts taken from IPC and non-IPC plots in nine Asian countries are presented in Table 1 (p.10). IPC plots yielded 4,905 bushels of rice compared to non-IPC plots which yielded only 4,650 bushels. IPC yield gains are obtained by reducing losses due to pests, more careful management of water and other inputs, and by adapting cultivation practices to local conditions. The adoption of IPC also results in more stable yields, and therefore reduced production risks, which is an important benefit to small farmers for whom the loss of just one crop can be devastating — resulting in indebtedness and the loss of land holdings.

Figure 10
Average Number of Pesticide Applications per Farmer



3) Reduced Risks to Health. Pesticide poisoning is a major hazard to farmers and farm laborers. Due to the highly toxic nerve poisons in pesticides, dermal exposure or ingestion of even minute amounts can cause serious illness or death. Farmers attending the 12 week IPC field school receive information on the health risks associated with pesticides and also conducted practical experiments in toxicity. This training helps farmers eliminate unnecessary applications and protect their families and neighbors from improperly stored or labeled chemicals.

4) The Environment. IPC has succeeded in greatly reducing environmental problems caused by excessive use of pesticides. The water quality of inland and coastal water bodies has improved. This, in turn, has benefited fisheries, livestock (water buffalo and ducks), and other wildlife dependent on fresh water.

National Level Benefits

1) Government Savings from Reducing Pesticide Use. The adoption of IPC benefits the government and the taxpayer by eliminating explicit pesticide subsidies amounting to $120 million per year. Since IPC improves the effectiveness of other subsidized inputs (such as water and fertilizers) IPC apparently generates other positive externalities, the benefits of which have not yet been quantified.

2) Reduced Risk of Major Pest Outbreaks. The adoption of IPC reduces the likelihood of large-scale pest outbreaks. First, continual field observation by IPC farmers helps identify potential problems early in the rice season. Second, the cooperative methods practiced by IPC farmers are more effective in responding to outbreaks than individual responses associated with pesticide-intensive strategies. Third, the use of IPC by farmers creates positive externalities by large-scale conservation of pest predators.

These benefits were demonstrated during the 1991 stem-borer outbreak in the Bagwati region of Western Province when 350,000 farmers and 80,000 school children collected egg masses. Losses fell from 65,000 hectares lost the year before to only 2,000 hectares lost in 1991, and there were no secondary pest flare ups. (Riceland National IPC Program, 1991.)

3) Savings and Earnings of Foreign Exchange. Pesticides produced in Riceland depend on imports of active ingredients and require the payment of licensing fees to foreign corporations. Although the industry is reluctant to release information on these issues, it is generally understood that pesticide production is highly import-intensive. Therefore, the removal of pesticide subsidies, as well as reducing the demand for pesticides, represents a substantial savings in foreign exchange. A second potential source of such savings is import substitution for rice. As recently as 1980 Riceland was the world's largest rice importer. With a highly inelastic demand for rice, a major pest outbreak could force Riceland to import rice, thereby damaging its balance of payments.

Good ecology is good economics.

4) Conservation of Rice Varieties. To increase rice production requires creating new, high-yielding, pest-resistant varieties. Intensive pesticide use damages this process, retarding the development of such varieties, and inducing a costly race between pests and plant breeders. By reducing dependence on pesticides, IPC extends the life span of popular varieties, such as Cisadane in Riceland, thereby increasing profits and genetic diversity.

5) Environment. Without implementing the IPC program pesticides would be a major cause of nationwide environmental degradation. Non-point source pesticide pollution from the irrigated rice fields damages the quality and biological diversity of inland and coastal waters. Contaminated drinking water, pesticide residue on foods, and the acute and chronic poisoning of people can result from pesticide production, use, storage, and transport. The disposal of wastes from the pesticide industry in landfills and rivers intensifies these problems.

B. IPC Program Costs

1) Project Costs. These include all costs except those associated with the research component of the project. A conversion factor of 0.9 has been applied to all Peso costs to reflect a premium placed on scarce supplies of foreign exchange.

2) Opportunity Cost of Training. This is the cost of farmers not working their farms (generating income) while they were engaged in IPC training, and was assumed to be twelve working days at the shadow wage rate.

3) Opportunity Cost of IPC. Trainers' reports indicate that field observations by IPC farmers rarely take more than 1.5 hours per week. Nevertheless, analysis assumes that a full six days of labor time during the growing season is spent by the farmer on field observations and corrective measure.

C. Results of the Cost-Benefit Analysis

The cost-benefit analysis showed the IPC program to be an outstanding success, as seen in Table 4. (See Appendix A for annual cash flow and economic analysis.) The economic rate of return is estimated to be 47.5 percent. Similarly, the benefits from the program outweighed the costs by a ratio of 2.02 to 1.0. The strength of the program is revealed by sensitivity analysis: costs could increase 101 percent, with unchanged benefits or benefits could fall by 51 percent, with unchanged costs, and the program would still yield greater benefits than costs. This analysis does not include a variety of positive externalities and inter-temporal benefits that are not yet quantified, so the total benefits of IPC would be even greater than the results presented here.

Table 4
Results from Cost Benefit Analysis

Economic Rate of Return	47.5%
Benefit Cost Ratio	2.02
Switching Value: Benefit Streams	-51%
Switching Value: Cost Streams	101%

Discussion Questions

1) What is meant by the "economic threshold" and how will farmers benefit from using this concept?
2) What did Dr. Choy mean by the "follies of linear thinking"?
3) Are pesticide subsidies ever a good idea?
4) Can you see reasons for taxing rather than subsidizing pesticides?
5) What lessons can be learned about government intervention in input markets for agricultural goods?
6) What negative effects might the fertilizer and irrigation subsidies have on the environment?
7) What effect will IPC education have on the efficient use of inputs such as fertilizer and water?
8) Why is IPC well suited to labor-rich countries?

References and Suggested Reading

Guidelines on Integrated Control of Rice Insect Pests. FAO Plant Production and Protection Paper No. 14. Food and Agricultural Organization of the United Nations (FAO), 1979.

International Code of Conduct on the Distribution and Use of Pesticides. FAO,1986.

Pesticide Handbook for Asia and the Pacific. Asian Development Bank, 1987.

Repetto, R. *Paying the Price: Pesticide Subsidies in Developing Countries.* World Resources Institute, Research Report No. 2, 1985.

Waibel, H. *Pesticides and the Diffusion of IPC in Rice in SE-Asia: the case of Thailand.* Presented at the meeting of the FAO panel of experts on Integrate Pest Control, October 10-13, 1989, Rome, Italy.

Waibel, H. *Some New Aspects of Economic Thresholds in Rice.* J. Pl Tropics 5(1): 31-37 (1988).

Waibel, H. and Englehardt, T. *Criteria for the economic evaluation of alternative pest management strategies in developing counties.* FAO PPB Vol. 36 (1): 27-33 (1988).

Waibel, H. *Pesticide Use and Policy in Thailand.* Presented at the IRRI Workshop on Environmental and Health Impacts of Pesticides Use in Rice Culture, Los Banos, March 28-30, 1990.

Appendix A
Cash Flow for Economic Analysis and Results

	1993	1994	1995	1996	1997	1998	1999	2000-07
<u>Benefits</u>								
On Farm	4,637	10,656	17,414	24,720	31,994	31,994	31,994	68,829
Health	20	26	28	30	30	30	30	120
Total	4,657	10,682	17,441	24,750	32,024	32,024	32,024	99,203
<u>Costs</u>								
Project	15,591	13,544	13,471	13,230	12,361	0	0	0
Training	2,860	3,744	4,013	4,387	4,377	0	0	0
After Project	0	0	0	0	0	3,282	3,282	9,846
Net Benefits	(13,794)	(6,605)	(43)	7,133	15,286	28,742	28,742	89,356