AN ECONOMIC EVALUATION OF THE HEALTH AND ENVIRONMENTAL BENEFITS OF THE IPM PROGRAM (IPM CRSP) IN THE PHILIPPINES

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AN ECONOMIC EVALUATION OF THE HEALTH AND ENVIRONMENTAL BENEFITS OF THE INTEGRATED PEST MANAGEMENT PROGRAM (IPM CRSP) IN THE PHILIPPINES

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(ABSTRACT)

Concern about externalities associated with pesticide use in developing countries has motivated the development of integrated pest management (IPM) programs in these areas. In the Philippines, the IPM Collaborative Research Support Program (IPM CRSP) was established to specifically address the widespread misuse of pesticides in the rice-vegetable systems of Nueva Ecija, one of the major rice and onion producing regions in the country. IPM CRSP initiatives include research on the optimal use of pesticides, complementary weed control strategies, and alternative cultural and biological controls. If successful, the program should generate benefits that can be measured in economic terms. These benefits include improvements in water quality, food safety, pesticide applicator safety, and long run sustainability of pest management systems.

This study was designed to measure the health and environmental benefits of the IPM CRSP in the Philippines. A survey questionnaire was administered to 176 onion farmers in five villages in Nueva Ecija to identify farm and farmer characteristics, pesticide usage, pest management practices, perceptions about pesticide hazards, awareness of IPM strategies, and willingness to adopt specific technologies being developed under the IPM CRSP. In addition, a contingent valuation survey was used to elicit farmers' willingness-to-pay to avoid risks posed by pesticides to different environmental categories.

A comprehensive economic measure of the benefits of IPM CRSP was derived by 1) assessing the hazards associated with pesticide usage, 2) providing an ex ante measure of program impacts on pesticide usage, 3) predicting IPM adoption rates, and 4) estimating society's willingness-to-pay to avoid the health and environmental risks from pesticides under Philippine conditions. A measure of the amount of risks avoided as a result of IPM CRSP adoption was combined with farmers' willingness to pay bids for risk avoidance to derive a monetary value of the program benefits. The estimated economic benefits of the IPM CRSP to farmer residents in 5 villages in Nueva Ecija amount to 230,912.00 pesos for one onion season.

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CHAPTER ONE

INTRODUCTION

Concern about the health and environmental effects of pesticides have increased over the past several years. This concern is evident from the increase in scholarly work on the environmental impacts of pesticides in the United States and in Europe. Unfortunately, research of this type is sparse in developing countries despite rampant overuse and misuse of pesticides in these countries.

Since agriculture is a major source of income in most third world economies like the Philippines, crop damage from pest infestation often result in dire consequences. The farmers therefore tend to be risk-averse with respect to pest management. This often results in misuse of pesticides especially because most farmers rely solely on chemicals for pest control. Without consideration of external costs, the net benefits of pesticide use tend to be overestimated. With widespread lack of understanding about the hazards caused by pesticide use, the problem of pesticide misuse and consequent environmental degradation in the third world seems imminent.

This study attempts to make a significant contribution to environmental research in the Philippines, particularly on pesticide impacts. The study identifies the hazards posed by pesticide use to different environmental categories, estimates the value of reducing the hazards, and evaluates the benefits of an integrated pest management (IPM) program in the Philippines, a country that makes heavy use of pesticides in agricultural production.

Problem Statement

Agricultural pests can cause significant reductions in farm yields and incomes. Consequently, pesticides are heavily used in attempts to mitigate this problem. However, there are serious negative externalities related to human health and the environment that are caused by over-application of these pesticides. Alarming statistics document the threat to farmers, pesticide applicators, and harvesters in developing countries. For example, according to a World Bank document, breast milk samples from women in cotton producing regions in Guatemala and Nicaragua have some of the highest levels of

DDT[1] ever recorded in humans. Furthermore, the illness and mortality rates from pesticide poisoning in these areas approach those of major diseases (World Bank, 1992). In the Philippines, hospitals under the jurisdiction of the Department of Health recorded 4,031 cases of acute pesticide poisoning, and 603 cases resulted in death over the period 1980-1987. This number is likely to be underestimated since most cases do not reach the hospitals, and rural health officials may not always correctly diagnose pesticide poisoning (Castaneda and Rola, 1990).

Prolonged exposure to pesticides has been associated with several chronic and acute health effects like non-Hodgkin's lymphoma, leukemia, as well as cardiopulmonary disorders, neurological and hematological symptoms, and skin diseases (Blair and White, 1985; Hoag et al., 1986; Wigle et al., 1990; Pingali et al., 1994; Crissman et al., 1994; Antle and Capalbo, 1994).

Methods for safe storage, handling, and application of pesticides that may lessen health and environmental hazards do exist and are widely used in many developed countries. However, use of these safety precautions is not widely observed in most developing countries (Rola and Pingali, 1993; Crissman, et al., 1994) for the following reasons: lack of awareness about the possible risks, lack of information on product use, inconvenience involved in trying to avoid contact with pesticides, pricing policies, and lack of regulations to mitigate these hazards.

Aside from human health effects, overuse of pesticides can also result in serious environmental damage to surface water, groundwater, and air quality, which consequently harm birds, aquatic species, mammals, as well as beneficial insects (also called natural pest enemies). Finally, misuse of pesticides could harm the predator-prey balance and result in higher levels of pest infestation and disrupt the existing ecosystem balance (Mullen et al., 1997; Higley and Wintersteen, 1992). In fact, scientists at the International Rice Research Institute (IRRI) already have found that injudicious use of insecticides in the Philippines, particularly early in the growing season, has disrupted the natural ability of the rice ecosystem to cope with pest infestations.

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[1] dichloro-diphenyl-trichloro-ethane, a colorless odorless water-insoluble crystalline insecticide; DDT was banned for use in most countries due to its detrimental effects on the environment (particularly on birds).

The impact of pesticides on the environment and on human health is an issue that must be addressed in developing countries where environmental legislation is either nonexistent or is ineffective. The institutional and economic structures in the rural sector of developing economies are such that policy interventions are usually needed to reconcile long-term societal objectives and short-term individual objectives in pest control (Rola and Pingali, 1993). Farmers are usually focused on their families' survival and their general well being, and therefore are more likely to adopt practices and use resources in ways that are unsustainable from society's perspective.

In the Philippines, the government continually seeks increased self-sufficiency in food. This increased self-sufficiency hopefully should come at a minimal social cost. To minimize social costs, the Philippine government must provide farmers with the proper policy incentives to induce them to adopt sustainable practices. An understanding of the impacts of pesticide use on human health and the environment is needed in designing optimal policies to minimize the social costs.

Integrated Pest Management (IPM) is the main strategy being used by countries around the world to specifically address the overuse or misuse of pesticides in agriculture. IPM involves the use of cultural, biological, and chemical techniques to control pest populations. A good definition of IPM is provided by Flint and Van den Bosch (1981):

"IPM is the use of the best possible combination of methods to reduce and maintain pest populations below a level that would cause economic damage. It is based on a principle of optimum rather than maximum pest control. It constitutes a major component in an agricultural production system, which will allow sustained agricultural production with minimal deleterious effects on the producer, consumer, the agrosystem, and the environment in general."

In 1986, the Philippine government issued a directive to make IPM technology the core of its pest control policy in agriculture; however, its spread has been spotty. IPM activities in rice were initiated in the Philippines by the Food and Agriculture Organization (FAO) as early as the late 1970's (Rola and Pingali, 1993). In recent years, the Philippine Department of Agriculture and the International Rice Research Institute (IRRI) have been active in research, extension, and farmers' training in IPM. Most IPM training is devoted to identifying pests and natural enemies, recognizing appropriate thresholds, and recommending chemical control when pest populations exceed threshold levels.

The impacts of IPM programs, if successful, can extend beyond the economic effects on farms where IPM is adopted. The effects of IPM on water quality, food safety for humans and wildlife, pesticide applicator safety, and the long run sustainability of pest management systems all generate benefits that can potentially be measured in economic terms (Norton and Mullen, 1994).

In September 1993, The United States Agency for International Development (USAID) awarded a group of institutions led by Virginia Tech a grant for the Integrated Pest Management Collaborative Research Support Program (IPM CRSP). The Philippines was one of the primary host countries selected for IPM research particularly on the rice-vegetable farming systems. The Philippine Rice Research Institute (PhilRice), the International Rice Research Institute (IRRI), and the University of the Philippines at Los Banos (UPLB) serve as collaborating institutions for IPM research in the Philippines. The purpose of the program is to reduce crop losses, increase farmer income, reduce pesticide use, reduce pesticide residues on export products, improve IPM research and education capabilities, improve ability to monitor pests, and increase involvement of women in IPM decision making and program design in the host country sites and beyond.

IPM CRSP research in the Philippines was established in Nueva Ecija, the primary rice producing region and also a major source of onions for the country. IPM CRSP work began in March 1994 with a meeting of all the collaborating institutions and other resource persons. A Rice-Vegetable IPM Program was developed and research, technology development, and technology transfer efforts are ongoing. This study is part of the IPM CRSP research effort focusing on the economic measurement of the benefits and costs of IPM implementation in the Philippines. It involves an in-depth examination of both health and environmental impacts of pesticide use. A comprehensive measure of the environmental and health risks is developed to arrive at a more complete economic analysis of the impacts of pesticide use in the Philippines. The rice and vegetable farming systems in Nueva Ecija are a good target for IPM CRSP activities in that these farming systems involve heavy use and/or misuse of pesticides. Pesticides are often applied in inappropriate amounts to vegetables to capture any price premium attached to unblemished and "fresh" looking produce. The most widely used pesticides in this area are Category I and II pesticides, the most harmful in terms of toxicity.

Research Objectives

The overall objective of the study is to develop and test a method for assessing the economic value of environmental and health impacts of the IPM program in the Philippines. The study addresses a serious challenge facing agricultural researchers, that is, to develop an appropriate framework to analyze human health and environmental impacts of pesticide use and translate this into an aggregate economic measure. Ideally, the method should be designed to be sensitive to the socio-cultural and environmental conditions specific to a developing country like the Philippines, yet useful enough to be replicated if needed in other sites.

The specific objectives of the study are to:

1) identify alternative methods of measuring environmental and health savings resulting from reduced pesticide use through IPM;
2) measure the environmental and health benefits associated with the vegetable IPM program in Nueva Ecija using the most appropriate method; and
3) assess the policy implications for the Philippine government, of the environmental and health impacts.

The Study Area

The study site is San Jose, Nueva Ecija, located in Central Luzon, Philippines. This area is popularly known as the rice bowl of the Philippines. Because of its proximity to the capital city of Manila, Nueva Ecija supplies most of the rice requirements of the metropolis. San Jose is one of the three major cities in the province of Nueva Ecija, serving as one of the principal trading and commercial centers of the province. San Jose has a total land area of 18,725 hectares with a population of 92,083. More than 50 percent of the total land area is devoted to agriculture (9,628 has.). Sixty-nine percent of the agricultural land is irrigated and 31 percent rain-fed. In 1990, San Jose had a total of 4,752 farmers and about 62 percent of them managed farms of 1-3 hectares. Sixty-eight percent of the farms were rented or leased and 22 percent were fully owned.

Rice is the major crop in San Jose. About 3,380 farmers cultivate rice in irrigated land, while 1,373 farmers cultivate rice in rain-fed environments. San Jose also produces substantial amounts of vegetables during the dry season and is considered the heart of the onion growing area in the Philippines. Other field crops grown are corn, rootcrops, legumes, leafy vegetables and spices. The area contains eight retail outlets for pesticides, nine banks, and 34 farm cooperatives.

Nueva Ecija has been the target of several pesticide studies in the past. A farmer survey (Lazaro et al., 1995) and participatory appraisal activity with rice-vegetable farmers in Nueva Ecija found both heavy pesticide use on onions, eggplant, and yard long beans as well as apparent pesticide misuse. Rola and Pingali (1993) studied the area of Guimba, Nueva Ecija and found that frequent application of highly toxic chemicals has resulted in health damage from chemical exposure. Pesticide pricing and the regulatory structure combined with inadequate storage, unsafe handling practices, too short reentry intervals, and inefficient sprayer maintenance expose not just farmer applicators but their whole household to an increased risk of chemical poisoning. In a study by Huelgas (1989), it was concluded that constantly changing pest complexes, a widening range of insecticide products, and the absence of unique and specific control recommendations against insect pests all contribute to farmers' confusion regarding the type of chemical to use, the rate of application and timing of control. Two baseline surveys were also conducted in San Jose as part of the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) which began in 1994. Pest control practices in rice were found to be very similar with pest control practices in vegetables. In particular, early spraying by the farmers was common in both crops.

These studies suggest that there is a problem of overuse and misuse of pesticides in the area. Incomplete knowledge about pests and misperceptions about the risks/environmental and health impacts contributed to the inappropriate use of insecticides. Nueva Ecija should provide a rich source of information and insights regarding the direct and indirect costs of pesticide application.

Previous Research and Some Methodological Issues

The methodological challenge for this study is to develop a comprehensive measure of the environmental and health benefits of an IPM program in the Philippines, given the fact that most of these environmental and health impacts are not priced in the market.

Relatively little empirical work has been completed that attempts to estimate the aggregate environmental benefits of IPM programs (Norton and Mullen, 1994), even though increased attention has focused in recent years on the actual or potential environmental benefits of IPM. Measurement of these benefits is difficult because assessing the physical or biological effects of alternative levels of pesticide use under different IPM practices is not straightforward. Evaluation of the benefits associated with environmental effects has to be derived indirectly because market values for improved human health and environmental conditions do not exist.

Rola and Pingali (1993) provided a framework for evaluating pest management techniques being used in the Philippines, giving consideration to traditional factors such as input prices and production risk, explicitly including health effects of pesticides in the analysis. They compared prophylactic pesticide applications with integrated pest management and natural control practices. When health effects were considered in the study, the net benefits of pesticide use were negative. Antle and Capalbo (1994) also outlined a conceptual framework that can be used to test behavioral hypotheses and to measure health-productivity tradeoffs. They discussed how the framework could be used to assess solutions to the pesticide-induced health problems in developing countries. Following Antle and Capalbo, Crissman et al. (1994) quantified the interaction among production technology, environmental quality, and human health in Ecuador. They reported significant health problems that caused loss of labor, exorbitant private health care costs, a reduction in productivity and impairment in decision-making abilities. These studies focused primarily on the health hazards caused by pesticides. Few studies have considered the other environmental impacts of pesticide use.

Some studies conducted in the United States provide useful insights into possible approaches to measuring environmental risks and benefits associated with IPM. Kovach et al. (1992) compared the environmental impacts of traditional pest management strategies with IPM strategies. They categorized the different environmental impacts into four major components: farmers, consumers, workers, and ecological effects. A variety of databases on toxicity of pesticides in different settings were then used to further classify and weigh the environmental impacts of various pesticides based on dermal toxicity, chronic toxicity, fish toxicity, and systemicity. This weighting allowed them to arrive at an environmental impact quotient (EIQ) by pesticide. Kovach and colleagues however, did not attempt to place an economic value on these differences in environmental impacts.

Higley and Wintersteen (1992) on the other hand, were able to determine the relative importance and monetary value of avoiding several environmental risks caused by pesticides through contingent valuation surveys. They used the contingent valuation method (CVM) to assess the relative importance that individuals place on various environmental risk categories and the amount they would be willing to pay to avoid high, moderate, and low levels of risk from a pesticide for a single application on a per acre basis. They assessed the environmental risks of pesticides on three broad areas of environmental risk: water quality, non-target organisms, and human health. These categories were further subdivided into eight specific categories (surface water, groundwater, aquatic organisms, birds, mammals, beneficial insects, and humans (acute and chronic toxicity). This model provided a formal method for assessing aggregate environmental risk from pesticides at the level of the individual users, as well as the regional or national level. Weights used to arrive at an aggregate environmental risk quotient were arbitrary however.

The contingent valuation method is one of the few procedures available for estimating environmental benefits of pesticide use reductions that has a theoretical rationale for the weights used to aggregate across environmental categories. Contingent valuation studies provide respondents with information about a hypothetical action that would reduce the likelihood of an environmental problem such as pesticide exposure. Respondents are confronted with a question or questions about the maximum amount they would be willing to pay to reduce the problem.

CVM as a technique for valuation of environmental goods or amenities is quite controversial. Some argue that because of the hypothetical nature of the CV questions, the method is prone to informational, hypothetical and strategic biases. Others believe that with a well-constructed survey, these biases can be minimized so that CVM results can be as reliable and accurate as other market-based valuation techniques.

Other methods like hedonic approaches, averting behavior, and replacement cost techniques can also be useful depending on the availability of data, complexity of the analysis, and validity of assumptions.

While techniques have been developed for valuing environmental costs, there remain serious theoretical and practical problems with use of these techniques. Measuring outputs of interest such as environmental quality, health, and profitability requires good empirical measures. There is also a need to go beyond measuring cost-of-illness, which others have done before, and to develop a method for measuring the multiple environmental and health outcomes.

Another challenge is to develop a quantitative measure of IPM adoption, as IPM is a collection of practices designed to reduce reliance on pesticide use. An ideal measure incorporates both absolute risks from pest management in a crop and relative progress toward diminishing the risk.

This study attempts to come up with an appropriate method to measure the economic value of environmental and health benefits of the IPM program in Nueva Ecija, Philippines. It draws on methodologies used in previous research (Owens et al., 1997; Mullenet al., 1997; Teague et al., 1995; Pingali et al., 1994; Kovach et al., 1992; Higley and Wintersteen, 1992) to develop a conceptual framework suitable to situations in developing countries like the Philippines.

Organization of the Study

The next chapter takes a closer look at previous research and the state of knowledge on the valuation of environmental and health impacts of pesticides. A description of existing methods used to measure environmental costs and benefits is provided.

Chapter Three describes the research methodology. The analytical framework and theoretical context of the study as well as the step-by-step procedure in evaluating the IPM program are discussed. Chapter Four describes the design and implementation of the survey conducted in Nueva Ecija, Philippines from November 1997- February 1998. Chapter Five reports the results of the descriptive analysis of the survey data and the results of the evaluation of the IPM program. Finally, the conclusions and recommendations derived from the study are provided in Chapter Six.

CHAPTER TWO

LITERATURE REVIEW

This chapter covers relevant literature on pesticide research, integrated pest management, and environmental valuation techniques. It includes an historical overview of previous research, a description of the valuation techniques, and some empirical applications.

State of Knowledge and Previous Studies

High rates of adoption of synthetic fertilizers and pesticides accompanied the Green Revolution in Asia. At that time, economic research focused on determining the best methods to apply chemicals to increase productivity. This research involved identifying profit maximizing rates and measuring the contribution of these chemicals to the value of agricultural production. The economic models used were usually of the form:

Max_x E[profit] = (Price * Yield) - variable factor costs - fixed costs

subject to: Y = f(fertilizer inputs, pesticide inputs, other inputs)

This framework inherently assumes that there are no economic externalities associated with synthetic fertilizers and pesticides, and that producer utility is solely based on profits. Studies by Hexem and Heady (1978), Headley (1968), and Heady and Dillon (1961) exemplified this type of analytical framework.

In the 1970's, economists began to formulate decision rules for pesticide use based on a pest damage function. They incorporated the concept of economic injury levels—an important component of integrated pest management that was introduced by Stern et al. in 1959. Pesticides then became indirect contributors (based on pests being present) to productivity[2].

In the late 1980's and in the 1990's, research has expanded in focus from profitability to environmental issues. Evidence of externalities from pesticide use and private environmental benefits from reduced use of synthetic pesticides suggest that profitability alone is not a valid proxy for producer utility and certainly not for societal benefits. Farmers appear to care about the effects of chemicals on their health and on

[2] Studies of this kind were done by Feder, 1979; Talpash and Borosh, 1974; and Hueth and Regev, 1974.

environmental quality (Swinton, 1996). Using contingent valuation, researchers have provided evidence that farmers and others at least in developing countries, value health and environmental quality and are willing to pay for it (Owens et al., 1997; Mullen et al., 1995; Higley and Wintersteen, 1992). Furthermore, Beach and Carlson's 1993 study using hedonic price analysis found that actual herbicide prices reveal that water quality and user safety are important and valued attributes by producers. Likewise, households' willingness to pay for reduced nitrate contamination of groundwater were estimated through: averting expenditure studies (Abdalla, 1990; Abdalla et al., 1992; Abdalla, 1994; Van Kooten, 1996), contingent valuation research (Poe and Bishop, 1992; Van Kooten, 1996), and fuzzy logic methods (Van Kooten, 1996).

These studies indicate that producers and consumers indeed value environmental quality. Evidence of farmers' willingness to reduce agricultural chemical use provides motivation for further research in this area. If incentives are created to induce farmers to adopt IPM techniques so that pesticide use can be reduced, significant progress can be made towards achieving a safer environment for agricultural communities in the third world.

The trend in industrialized countries is moving towards a reduction in the use of agricultural chemicals because of evolving economic research into benefits and costs of agro-chemical use, innovations in the chemical and non-chemical agricultural technologies available, and changes in the legal and policy setting (Swinton, 1996). Factors that can influence the reduction in chemical use in industrialized countries are not always present in developing countries. For example, crop insurance that reduces yield risks is not widely employed in developing countries; chemicals that are banned in the U.S. are still widely used in these areas; environmental legislation has not been as aggressive as in the industrialized countries; techniques for the safe use of agricultural pesticides are far less widespread in developing countries; and a host of other factors make pesticide misuse and overuse a major problem in the Third World.

Integrated pest management in developing countries may help control the overuse of pesticides. According to Norton and Mullen (1994), increased attention has focused in recent years on the actual or potential environmental benefits of IPM. Much of the support for IPM research and extension has resulted from concerns over food safety, groundwater contamination, and increased environmental awareness (Mullen et al., 1997). So far, economic evaluations of IPM programs have focused primarily on farm-level profitability or risk studies (Ferguson and Yee, 1993; White and Thompson, 1982; Rajotte et al., 1987). Few studies have been completed that measure the aggregate economic benefits from IPM-induced cost reductions or yield changes because of methodological difficulties. Two reasons account for the difficulty in measuring these benefits—assessing the physical or biological effects of alternative levels of pesticide use under different IPM practices is not straightforward, and the economic value associated with environmental effects is not generally priced in the market. Despite these difficulties, it is still imperative that the benefits and costs of IPM are valued and analyzed, not only for policy direction but also for the development of new techniques and improvement of existing ones that are suitable for conditions found in developing countries. Research on environmental valuation techniques adapted to developing countries is still lacking.

There are a few valuation techniques used to quantify the value of an environmental good, service or environmental quality. These techniques vary by type of market they rely on and also by how they make use of actual or potential behavior. The following section describes these techniques and some applications.

Methods Used to Measure Environmental Costs and Benefits

Various methods can be used for environmental valuation. These methods can be classified in a number of ways. Environmental quality protection or improvements can be evaluated either from the benefit side or from the cost side. Environmental cost valuations were more common in the past because researchers found it more feasible to derive cost estimates rather than benefit estimates when operating within the restrictions placed by limited program funds, difficulties and complexity of the analysis, and data requirements. Cost estimates do not necessarily produce accurate estimates of the values of environmental goods or improvements, but can be used as approximations (lower bounds) for the true marginal values of the environmental good or amenity. Attempting to derive benefit estimates, despite the complexities involved is nonetheless a worthwhile undertaking for the purpose of establishing some kind of order of magnitude of the economic values and to be able to derive benchmark figures to compare across different valuation techniques. Estimation from the benefit-side is the preferred approach. It provides not only a minimum estimate of benefits generated, but a closer approximation to willingness-to-pay measures or the marginal value products.

There are also techniques that attempt to derive non-monetary measures of health and environmental costs. They use an efficiency frontier approach to illustrate trade-offs between financial and non-market utility attributes of agricultural chemical use (Hoag and Hornsby, 1992; Bouzaher et al., 1992; Chu et al., 1996; Wossink et al., 1996). This approach allows them to identify strategies that increase both costs and use of hazardous agro-chemicals that are not on the efficient trade-off frontier. The optimal choice of agricultural chemical strategy is left up to the preference of the decision-maker using the analysis. These studies have shown that marginal gains in environmental quality can be achieved at fairly low cost (a least cost approach).

Valuation from the Cost-Side

Most of the decisions about environmental quality are made without monetary estimates of benefits, but based on some specific goals or some kind of standard. Examples include, emissions, ambient concentrations of pollutants, and measures of community health. The resource costs associated with attaining these environmental goals are estimated to come up with the cost-side value of an improvement in environmental quality. The economic costs reflect the opportunity costs of resources allocated for environmental quality purposes instead of for other economic uses. And the economic value of resources committed provides, according to those incurring the costs, a minimum estimate of the benefits generated (Hufschmidt et al., 1983).

Another approach to valuation of the economic costs or benefits foregone through environmental damage is to measure the cost of replacing the environmental services destroyed. The implicit values of environmental quality benefits obtained, are also revealed in the willingness to incur defensive costs.

Valuation from the Benefit-Side

Benefits of an improvement in environmental quality can either be the value of increased production or the value of damages prevented. The techniques under these approach are based largely on consumer or producer willingness to pay for an improvement (or willingness to accept compensation for a deterioration) in environmental quality. Techniques can be also be classified according to the type of market they rely on and also by how they make use of actual or potential behavior.

Market-Oriented Approach

This approach makes use of actual market prices of outputs. The techniques under this approach can be grouped into: 1) methods for valuing environmental quality benefits using actual market prices to value output or loss of earnings, 2) valuation of costs using actual market prices, and 3) valuation based on surrogate markets (used when market prices for environmental services or project outputs, and external effects are not readily available).

Economic valuation of environmental quality effects based on market value or productivity approaches is reflected in the productivity of natural systems (physical and human) and in the products that derive from them and enter into market transactions. Environmental quality is viewed as a factor of production. Changes in environmental quality lead to changes in productivity and production costs, which lead in turn to changes in prices and levels of output that can be observed and measured. In looking at environmental and health impacts of pesticides, a more appropriate and realistic valuation method may involve the use of implicit markets, because of the fact that market prices do not exist for most pesticide impacts.

Valuation Using Surrogate (or Implicit) Markets

The methods and techniques under this category use market information indirectly. Surrogate markets are used to value goods and services affected by changes in environmental quality. Each technique has particular advantages and disadvantages, and specific data requirements.

1. Travel Cost. The travel cost approach is a way to value unpriced goods. Most often connected with recreational analysis in industrial countries, the travel cost method measures the benefits produced by recreation sites (parks, lakes, forests, and wilderness). In this method, the area surrounding a site is divided into concentric zones of increasing distance. A survey of users conducted at the site determines the zone of origin, visitation rates, travel costs, and various socio-economic characteristics. Users close to the site would be expected to make more use of it, because its implicit price, as measured by travel costs, is lower than that for more distant users. Analysis of the questionnaires

enables a demand curve to be constructed (based on the willingness-to-pay for entry into the site, costs of getting to the site, and foregone earnings or opportunity cost of time spent) and the associated consumer surplus can be determined. This surplus represents an estimate of the value of the environmental good in question (Munasinghe and Lutz, 1991).

This method implicitly considers the environment in terms of provision of recreational services rather than basic life-support services, which renders it inappropriate to use in this study. Also, while the travel cost method is able to estimate the value of environmental amenities associated with a specific site, the ubiquitous nature of the environmental effects of agricultural pesticides makes this method inappropriate for this kind of study (Mullen, 1996).

2. Hedonic Pricing Techniques. Hedonic pricing techniques infer the value of environmental amenities from the prices of other commodities. Hedonic pricing techniques attempt to disaggregate the price of commodities into sets of values for their various quality characteristics. Hedonic pricing techniques may be able to generate estimates of the value of some of the environmental categories, but probably not all.

Beach and Carlson (1993) used the hedonic pricing technique with pesticides. They showed that it is possible, in a diverse market, to use hedonic analysis on the average expenditure per application to estimate the shadow value of the marginal utility of herbicide characteristics in the United States. They found that objectively measured attributes of chemicals could explain relative prices of a wide range of herbicides even if farmer characteristics are not utilized. They further found that production variables (including those correlated with leaching) were the major product characteristics that explain herbicide use decisions.

The problem with the use of this technique for this study is that pesticide safety characteristics may only influence pesticide choices if information on these factors is widely known by farmers and chemical firm managers. Also, the prices of pesticides in the Philippine market may not necessarily reflect their true values or shadow prices.[3]

Some specific hedonic-type techniques include:

[3] Shadow prices reflect true values of the goods or services, taking into account distortions caused by fiscal and monetary policies, agricultural regulations, and market inefficiencies.

i) Property value. The property value method is based on the general land value approach. The objective is to determine the implicit prices of certain characteristics of properties. In the environmental area, the aim of the method is to place a value on the benefits of environmental quality improvements, or to estimate the costs of deterioration. The approach is based on a competitive real estate market, and its demands on information and statistical analysis are significant.

In the Philippines, agricultural land prices do not necessarily reflect environmental quality differences. Filipino farmers do not consider environmental and health risks in choosing which land to till and therefore these differences do not influence agricultural land prices as such. In fact previous studies conducted in the study area noted that farmers do not always understand the complexities of misuse and overuse of pesticides. Because property/land values in the study area do not reflect differences in environmental quality due to pesticide use, this method can not be used.

ii) Wage Differential. The wage differential approach is very similar to the property value approach. This method is based on the theory that in a competitive market the demand for labor equals the value of its marginal product and that the supply of labor varies with working and living conditions in an area. A higher wage is therefore necessary to attract workers to locate in polluted areas or to undertake more risky occupations. This method can only be used if the labor market is perfectly competitive. Another consideration is that this method relies on private valuation of health risks, not necessarily social ones. The level of information concerning occupational hazards of pesticide use must be high in order for workers to make meaningful tradeoffs between health risks and remuneration. The effects of factors other than the environment (like, skill level, job responsibility, alternative jobs available in the area, etc.) that might influence wages must be eliminated to isolate the impacts of the environment, making it difficult to implement this approach. Previous studies observed that Filipino farmers barely understand the health and environmental risks of pesticide use and that precautionary and safety measures in applying pesticides are often neglected. This lack of understanding implies that they may not be consciously aware of their occupational hazards and therefore do not demand remuneration accordingly. Further investigation is needed to determine if there are indeed differences in wages among work groups (harvesters, pesticide applicators, and so forth) and if farmers really discriminate among work groups at all.

Marketed Goods as Proxies for Non-marketed Goods

In situations where environmental goods have close substitutes that are marketed, the value of the environmental good in question can be approximated by the observed market price of its substitutes. An example would be estimating the demand for clean and safe drinking water indirectly, by using estimates of the demand for bottled water (a good that is priced in the market). However, for this study, the problem is to find a proxy for the environmental good or desired level of environmental quality in question.

Survey-Oriented Approach

In the absence of data on market prices, methods that rely on direct questioning of willingness to pay estimates or indirect estimation of willingness to pay via direct questioning on choices of commodities are used. These include contingent ranking, referenda, and the contingent valuation (CV) method. In the absence of people's preferences as revealed in markets, the contingent valuation method tries to obtain information on consumers' preferences by posing direct questions about willingness to pay. It basically asks people what they are willing to pay for a benefit or what they are willing to accept by way of compensation to tolerate a cost (or both). What is sought are personal valuations of the respondent for increases or decreases in the quantity of some good, contingent upon a hypothetical market. The CV technique is one of the few procedures currently available for estimating aggregate environmental benefits of IPM programs. The reliability of this technique however has been subject to a lot of question. Some have argued that the respondents give answers that are irrational; that they do not understand what they are being asked to value; that they do not take the questions seriously because of their hypothetical nature. The CV method has certain problems indeed, including problems of designing, implementing and interpreting questionnaires. While its applicability may be limited, there is now considerable experience in applying this survey-based approach in developing countries. Some have argued that with a proper survey design these associated problems can be minimized (Mitchell and Carson, 1989; Navrud, 1989; Cummings, 1986).

An example of the use of contingent valuation on pesticides was provided by Higley and Wintersteen (1992). They employed contingent valuation techniques in an attempt to place an economic value on the benefits of reducing pesticide risks. CV was used to assess the relative importance that individuals place on the environmental risk categories and the amount they would be willing to pay to avoid high, moderate, and low levels of risk from a pesticide for a single application on a per-acre basis. Environmental risks of pesticides were assessed based on three broad areas of environmental risk (water quality, non-target organisms, and human health) that were then subdivided into eight specific categories (surface water, groundwater, aquatic organisms, birds, mammals, beneficial insects, humans (acute and chronic toxicity). Each pesticide was classified into high, medium, low or no risk for each environmental category based on a set of criterion from several different studies. Similarly, Mullen et al. (1997) used the CV method to estimate willingness to pay and calculated the economic value of the environmental benefits of an IPM program.

Other Methods of Environmental Assessment

Other methods have been used to address specific types of environmental effects. One such method is the *Avoidance Cost Method (ACM).* The avoidance cost method offers a means for generating lower-bound estimates of an important component of benefits like the use of groundwater as a source of drinking water[4]. From a public decision-making standpoint, the benefits of groundwater protection can be viewed as damage avoided from groundwater contamination. Major categories of damage include: human health, increased fear and anxiety, avoidance cost and property value loss, ecological damage and loss of recreational use, and reduction/loss of nonuse values. The ACM is operationalized by estimating the costs of behavior to prevent or mitigate adverse impacts of pollution. It infers benefits of measuring consumption of goods and services that substitute for the environmental quality change. Analyses using the avoidance cost method have shown that observed averting costs only provide a lower bound to willingness-to-pay measures (Abdalla, 1994) and when these estimated costs are used as proxies for willingness to pay estimates, are subject to potential errors in

[4] The theoretical basis for the averting expenditure approach, which is rooted in the household production function model, is contained in Courant and Porter (1981); and Bartik (1988).

interpretation (Segerson, 1994). Another issue is that the average expenditure on avoidance for those who chose to avoid the contamination is not a measure of (or even a lower bound for) the average willingness to pay for the entire population since it does not incorporate the lack of any expenditures by some portion of the population (since avoidance costs reflect actual expenditures, conditional on the individual's expectations regarding what others will do to reduce exposure to the contaminant).

For changes in environmental quality that specifically affect human health, the monetary costs associated with the health effects are estimated. The monetary damages associated health effects consist of three major things: foregone earnings through premature death, sickness, or absenteeism; increased medical expenses; and psychic costs. There are studies that evaluated the economic impacts of acute human health effects associated with pesticide use in developing countries (Rola and Pingali, 1993; Antle and Pingali, 1994; Crissman et al., 1994; Antle and Capalbo, 1994; Pingali, et al., 1994).

Antle and Capalbo (1994) presented a conceptual framework for testing behavioral hypotheses and to measure health productivity trade-offs concerning pesticide use in developing countries. They modified the health and consumption models used in the environmental economics literature to include farm and household production activities.[5] Their model included both the productive and intrinsic values of health. The productive value of health can be estimated using wage equations and production functions (Strauss, 1986). Antle and Pingali (1994), used a health production function in combination with a crop cost function to estimate the value of pesticide related health impairment in agricultural production. These procedures provide measures of the economic value of health in terms of goods that have market prices. An advantage of this approach according to them is that impacts of health impairments on productivity can be measured whether or not the farm decision-maker is assumed to understand the health consequences of pesticide exposure.

The intrinsic value of health on the other hand, can be estimated using methods developed to value non-market goods. Some of these methods, as described in the earlier

[5] See Freeman and Cropper (1991) for specific health and consumption models.

section require the assumption that individuals in the population understand the health risks associated with exposure to a hazardous situation.

Crissman et al. (1994) followed the methodological guidelines laid out by Antle and Capalbo to quantify interaction among production technology, environmental quality, and human health in Ecuador. Using project instituted active surveillance methods and trained health professionals they reported a number of health consequences of pesticide use including acute poisoning, chronic dermatitis, and chronic central nervous system damage. These health problems caused loss of labor, considerable private health care costs, a reduction in productivity and impairment in decision-making abilities.

In the Antle and Pingali (1994) study, it was found that pesticide related health impairments caused significant reductions in labor productivity. Using the same sample, Pingali et al. (1994) studied the impact of prolonged pesticide use on farmer health. They quantified the magnitude of chronic health effects and health costs directly related to pesticide exposure. A set of medical indicators of pesticide exposure including farmer characteristics was used.[6] Their valuation of health costs of pesticide exposure was based on medical tests that looked at treatment costs required to restore farmers' health (i.e., medication, doctors' fees, opportunity cost of time lost). When the estimated health costs were incorporated in their benefit-cost calculations, the net present value of pesticide use was found to be negative.

This cost-of-illness approach by Pingali et al. only yields a lower bound to health costs.[7] Ideally, it is also important to know what people would pay to avoid becoming ill, this amount includes not only the cost of illness but also the cost of pain and inconvenience of being ill. Studies that ask people how much they would pay to avoid an adverse health outcome should be able to overcome three obstacles. They must carefully define the health outcome being valued, or they must allow the respondent to characterize the severity of the health outcome himself. They must also make sure that the respondent is aware of the consequences of the health outcome, including the time that would be lost from work and the associated medical expenses. Finally, they must make sure that the respondent carefully considers the budgetary implications of his willingness to pay

[6] Pesticide exposure = f (age, nutritional status, history of tobacco and alcohol consumption, occupational exposure to insecticides and herbicides).

[7] Health costs are composed of medical expenditures plus time spent recuperating from illness.

response (Cropper, 1994). Despite the difficulties in doing these, it is not impossible to develop survey schemes that would achieve these requirements.

Conclusion

One of the main goals of this research is to develop an analytical tool that will provide a comprehensive measure of IPM benefits, applicable to the IPM situation in the Philippines. Mullen et al. (1997) demonstrated how this could be accomplished using the peanut IPM program in Virginia. This method can be difficult to implement in a developing country like the Philippines because of problems of data availability and reliability. Moreover, due to different political, cultural, and legal structures in the Philippines, development of new assessment procedures may be warranted.

The literature review provided useful valuation techniques that are currently being used by researchers. As seen, most are not appropriate for the Philippines. The non-market valuation methods require the assumption that individuals understand the link between some action, such as pesticide exposure, a non-market good such as health, and their personal well-being. This association is questionable in a low-income, rural farm setting where information about such linkages is not readily available or literacy may limit individuals' ability to understand them (Antle and Capalbo, 1995).

The contingent valuation method is probably the most feasible technique to use. Modifications to the usual CV method are however needed to limit some of the biases inherent in the method. The framework of analysis and the step-by-step methodology are presented in succeeding sections.

CHAPTER THREE

METHODOLOGY

Economic efficiency, that is, getting the most welfare out of a given endowment of resources is one of the primary concerns in an undertaking such as evaluation of a public program especially given today's tight budgets. Prioritization of public projects has to be done in such a way that resources are invested in their most productive and beneficial uses. Hence, the goal is to identify the alternative that will make the most efficient use of society's scarce resources in promoting societal objectives, that is, providing maximum net social benefits.

Economic analysis of a project usually involves evaluation of its costs and benefits. Most studies tend to focus on looking at private costs and benefits. A more holistic approach incorporates the environmental costs/benefits including other social or external concerns. This task however appears to be daunting because deriving reliable and accurate values for these social costs or benefits when market prices are not available entails special techniques (i.e. non-market valuation) that are often difficult to implement.

For evaluating a program like IPM, it is essential that the environmental benefits are incorporated in the analysis, especially since one of its main objectives is to lessen environmental degradation. There is no doubt that the use of pesticides in agriculture generates negative externalities. Pollution is the consequence of an absence of prices for certain scarce environmental resources and so surrogate prices are needed to provide signals to economize on use of these resources.

The basis for deriving measures of the economic value of improvements in the environment is their effect on human welfare (economic value and welfare change). Society should make changes in environmental and resource allocations only if the results are worth more in terms of individuals' welfare than what is given up by diverting resources and inputs from other uses (Freeman, 1979).

Benefit-cost analysis (BCA) provides the conceptual framework to organize a coherent approach to the problem of incorporating environmental and health impacts into public policy analysis (Antle and Capalbo, 1995). It provides the foundation for developing the framework for valuing chemical externalities. The framework of analysis needs to make the link between the physical changes in environment and resource quality attributable to agricultural practices and the valuation attached to those changes in environmental quality and health. Figure III.1 provides a schematic diagram of the benefit-cost analysis framework regarding a change in pesticide use (adapted from Antle and Capalbo, 1995).

The methods used in estimating the values that society places on the reduction of risks to health and the environment draw on theory of individual preferences and demand for goods. The premise is that individuals are the best judge of their own welfare and that inferences about welfare can be drawn for each individual by observing the individual's choices among alternative bundles of goods (goods and services, government and environmental services and time). The basic concept of economic valuation underlying all techniques is the willingness to pay of individuals for an environmental service or resource. Willingness to pay can be estimated through derivation of the demand function for an environmental asset, through analysis of actual behavior, or can be elicited through controlled experiments or direct interviews.

WTP is defined as the maximum amount of money that the individual would be willing to pay rather than do without an increase in some good such as an environmental amenity. It is the amount of money that would make the individual indifferent between paying for and having the improvement and foregoing the improvement while keeping the money to spend on other things. Willingness to pay is constrained by individuals' income.

Economists seek measures of values that are based on preferences of individuals when value measures are derived via indirect methods based on models of behavior. These models should be internally consistent and be based on accepted theories of preferences, choice and economic interactions.

The need for an economic measure of the health and environmental impacts of pesticide use is warranted not only to guide policy making but more importantly in this case to determine the value or the benefits of the IPM program in terms of improvement in society's welfare. To translate unit benefit estimates/values into benefits of an environmental program, requires three steps:

1) the pollution reductions associated with the program must be related to changes in environmental quality;

2) the change in ambient environmental quality must be related to health or other outcomes preferably through a dose-response function; and
3) the health or non-health outcome must be valued.

The following section provides a detailed description of the methodology of the study.

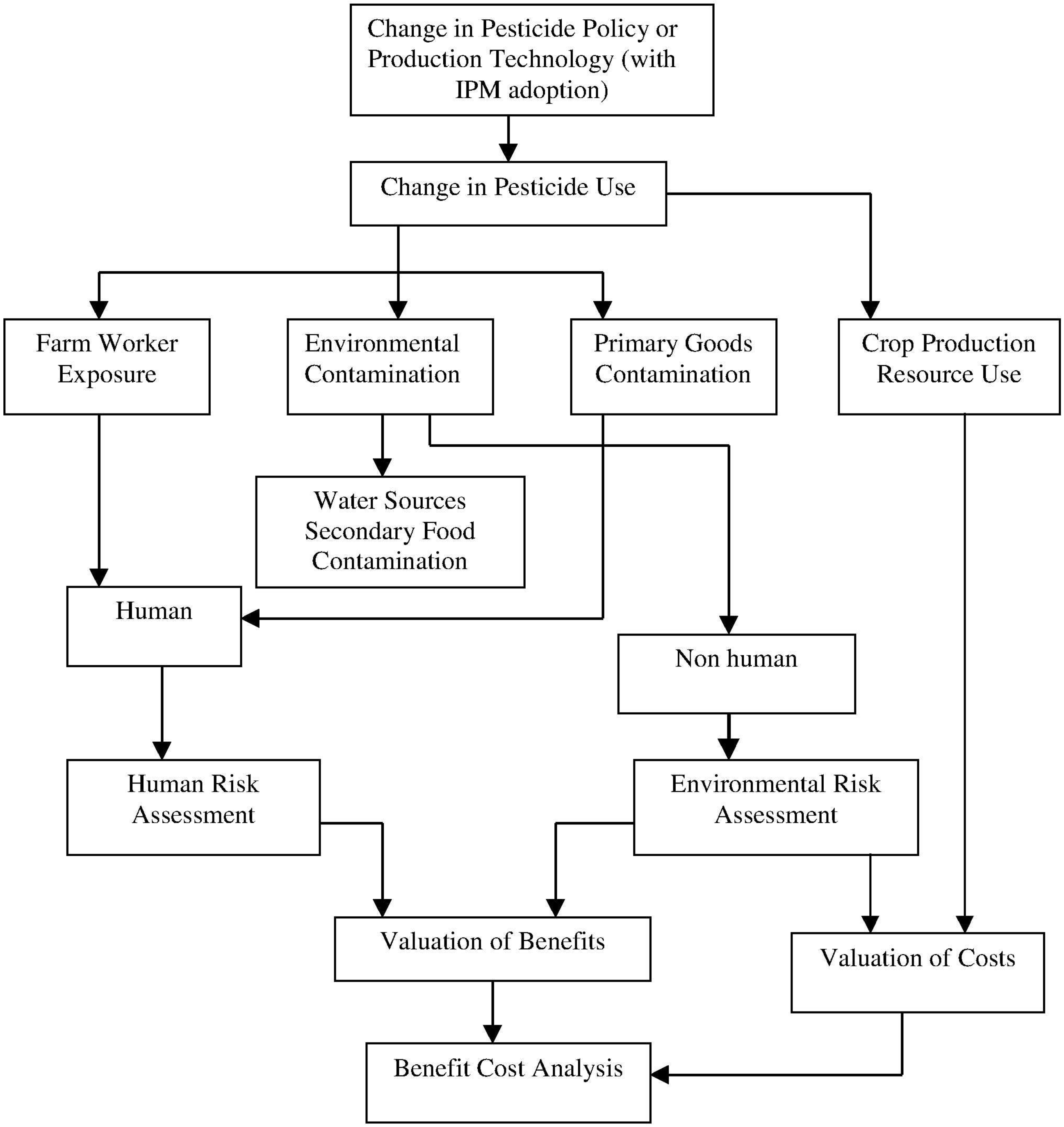

Figure III.1: Major Components of a Benefit-Cost Analysis of a Change in Pesticide Use

Source: Antle and Capalbo (1995)

Evaluating the Benefits of an IPM Program

An approach to evaluating the benefits of an IPM program, particularly the IPM-CRSP in the Philippines is presented in this chapter. The goal is to derive a monetary value of the benefits to society of the pest management program in terms of its effectiveness in improving the quality of the environment. This is accomplished by estimating 1) the impacts of the program on the risks caused by pesticides to various non-target species and 2) society's willingness-to-pay to reduce these risks. These two estimates provide the bases for the economic assessment of the environmental and health impacts of the IPM-CRSP in the Philippines.

Figure III.2 provides an illustration of the step-by-step evaluation process. The methodology starts with the identification and classification of the relevant environmental categories that are affected by pesticide use. The impact categories are classified according to the type of non-target organisms affected—humans (chronic and acute health effects), birds, beneficial insects, aquatic species, and farm animals (mammals). The next step is an environmental impact assessment of the consequences of pesticide use on the identified impact categories. The objective of this second step is to determine the degree or severity of the impacts of pesticide use in the region. This involves estimating the risks posed by individual pesticide active ingredients to the impact categories by approximating toxicity levels and exposure levels of the organisms to the toxic substance. The impact of a chemical active ingredient is then determined by combining risk estimates with actual field use (dosage and concentration of active ingredient in the formulation). Then, to be able to measure the benefits of the program, the level of adoption of IPM in the region should be determined. The degree and level of adoption of IPM technologies can be predicted using econometric models and inferred from past IPM adoption rates.

The fourth step establishes the impacts of the IPM program on pesticide risk reduction. Individual IPM technologies are evaluated based on their potential to reduce the use of insecticides, herbicides, fungicides, and other pesticides by a certain percentage. This change in the degree of pesticide impacts brought about by changes in pest control activities due to IPM is calculated and combined with the estimate of society's willingness-to-pay for the reduction in pesticide impacts (inferred from a contingent valuation survey). Hence a monetary value for the benefits of the IPM program is obtained.

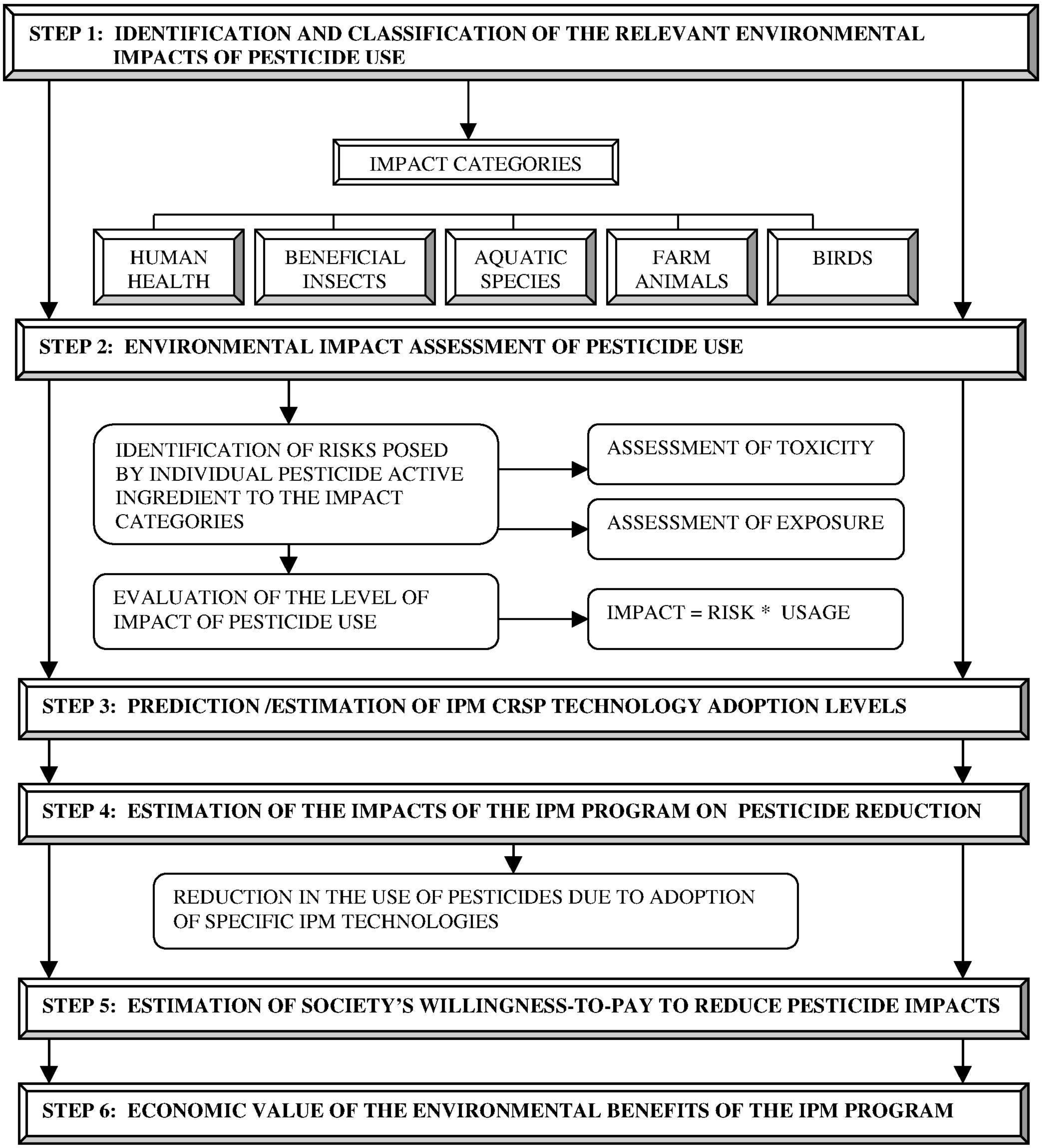

Figure III.2 An Approach to Evaluating the Economic Value of the Health and Environmental Benefits of an IPM Program

Step 1. Identification and Classification of the Relevant Environmental Impacts of Pesticide Use in the Study Area

This step establishes the environmental parameters for assessing the impacts of the pest control activities in the study site. The ubiquitous and diverse nature of the externalities caused by pesticide use warrants targeting the most relevant parameters for evaluation and classifying them into specific impact categories.

The social and environmental consequences of pesticide application encompass the following: 1) human health – which can be further classified according to impacts on farm workers (applicators and pesticide handlers), consumers, and the general public. Human health impacts can also be evaluated according to vulnerability of specific sub-populations like children, the elderly, people with respiratory problems, asthma patients, and the like; 2) lethal and sub-lethal impacts on other non-target biota – birds, aquatic species, soil organisms, plant life, mammals, etc.; 3) direct and indirect impacts on natural and agronomic ecosystems, including effects on habitat and food sources; 4) consumption and degradation of natural resources (Levitan, 1997).

There are various approaches to classifying pesticide impacts. Kovach et al. (1992) used three components in the calculation of the Environmental Impact Quotient (EIQ): 1) the farm worker component (pesticide applicators and pickers), 2) the consumer component, and 3) the ecological component (birds, bees, beneficial arthropods, and aquatic species). The 'Ipest Model' assesses impacts based on three element of the natural environment: 1) groundwater, 2) surface water, and 3) air quality (van der Werf and Zimmer, 1997). A U.C. Berkeley study used human health, ecological health (avian species, invertebrates, fish), and natural resources as parameters for a pesticide evaluation model (Pease et al. 1996). The following section describes the classification scheme deemed appropriate for this study.

Impact Categories

The external costs of pesticide application are classified according to the type of organisms affected. Pesticides pose hazards to organisms through groundwater pollution, surface water pollution, air pollution and through direct contact with pesticides or indirectly through food residues. These are the various routes or modes by which different organisms are exposed to toxic pesticide ingredients. The risk of exposure increases with the level of resource degradation and amount of residues in food. Therefore, the degree of pesticide impacts on these routes/modes serve as exposure indicators used to quantify potential health risks to the different organisms. In other words, impairments to natural resources (water, air, soil) are not included as impact categories but are used as measures of potential exposure.

The most important parameters specific to the rice-vegetable farming system in the study area are presented below.[8]

Human Health

The risk that pesticides pose to human health is an immense concern because of the chronic and acute illnesses attributed to pesticide exposure. Medical studies have correlated pesticide use with dermal, respiratory, neurological, gastrointestinal, eye, and kidney problems. The adverse impacts to farm worker productivity and the exorbitant costs of medical treatments due to pesticide exposure have been well documented and established in the literature (Pingali et al., 1994, Antle and Pingali, 1994, Rola and Pingali, 1993).

There is a need for intervention in preventing pesticide misuse in developing countries because of the greater health risks brought about by misperceptions and economic and institutional factors. The lack of awareness about pesticide externalities, inadequate protective measures against exposure, damaging agricultural policies that provide incentives for chemical use, and very limited environmental legislation that addresses the problem, account for the rampant misuse of pesticides and serious health risks in third world farming communities. Therefore, looking at the consequences of pesticide use on human health and the benefits of the IPM program in terms of reduced risks to human health is crucial to this study.

Chronic and acute illnesses are brought about by human exposure to pesticides- through the skin when pesticides are mixed and/or sprayed, inhalation of pesticide particulates in the air, through pesticide residues in fresh produce, and by drinking contaminated water. Toxic pesticide pollutants therefore may pervade the immediate farm environment, consequently affecting most of its residents. It can be difficult to

[8] Farmers' attitudes and beliefs toward pesticide risks based on an earlier exploratory study were considered in identifying the impact categories used in this study.

distinguish among different groups in a farming community since the farm workers-- the harvesters and the applicators-- are also the consumers, and are also considered the "general public" (referring to residents that are affected by contaminated water and food, or polluted air). For this reason, the human health category incorporates all these sub-groups into one major group without any distinction among them. The human health category encompass all the people living in the study area (the farming community). Human health impacts are evaluated based on chronic and acute effects.

Beneficial Insects/Natural Pest Enemies

The interactions between insects and their natural enemies are essential ecological processes that contribute to the regulation of insect populations. In situations where this interaction is disrupted, potential pest insects may be released from the constraints imposed by their natural enemies, and excessive population growth, which constitutes a pest outbreak, may occur (Dent, 1991). An outbreak of pest populations can happen when the population of natural enemies or beneficial insects is significantly reduced due to insecticide spraying. Unfortunately, farmers tend to see no other recourse but to increase pesticide application and/or use more toxic pesticides to control the outbreak and reduce crop losses. Hence, a vicious cycle ensues.

The importance of natural enemies as a biological pest control measure, makes it a major component of most integrated pest management programs. IPM research on biological control measures has intensified in recent years. Pesticide manufacturers are even getting on the bandwagon, promoting so-called biorational products[9]. Moreover, there is growing awareness among farmers about the usefulness of natural enemies in controlling pests and minimizing costs. In an exploratory survey conducted in the study site, a number of farmers were able to correctly identify dragonflies and spiders as beneficial insects.

The use of beneficial insects or natural enemies as an alternative to chemical control has important implications for optimal pest management– expenses on

[9] Biorational pesticides are based on the physiology or biochemistry of insects. This kind of insecticides are more selective against insects with certain feeding habits, at certain life stages, or within certain taxonomic groups. They are less harmful to natural enemies and the environment. Biorational insecticides include microbial-based insecticides such as the *Bacillus thuringiensis* products, chemicals such as pheromones that modify insect behavior, insect growth regulators, and insecticidal soaps (Hoffman and Frodsham, 1993).

insecticides are reduced, risks to human health and the environment are diminished, and secondary pest outbreaks are potentially eliminated. For these reasons most environmental impact studies on pesticide use consider effects on beneficial insects or arthropods as an integral parameter in the analysis.

Aquatic Species

Pesticide runoff to surface waters pose significant risks to aquatic organisms. Ingestion of toxins by aquatic species results in fishery losses and contamination of other seafood. Fish kills due to pesticides have been well-documented (Pingali and Roger, 1995). Interviews with farmers in the study site revealed that the populations of certain freshwater fish (i.e., mudfish, catfish, tilapia, *talandi*, *gurame*) that used to abound in rivers, lakes, swamps and even holes of dikes around the rice-onion fields has been dwindling over the years; yet, more noticeable is the significant drop in fish availability shortly after pesticide applications.

Much of what is known about the impacts of pesticides on the paddy/aquatic vertebrates is derived from laboratory and controlled experiments (Bajet and Magallona, 1982; NCPS, 1983; Tejada, 1985; and Tejada and Magallona, 1986). The following findings have been drawn from these experiments: 1) the absolute number of aquatic vertebrates declines rapidly with pesticide use, with mortality usually occurring within the first five to seven days after pesticide application; and 2) for the surviving populations, the level of detectable residues was generally small. Tejada et al. (1995) reported that in the wet season, all extracts of fish (tilapia, hito, mudfish) and freshwater shrimp revealed the possible presence of the chemical isoprocarb, a commonly used pesticide in the area.

In a study by Price (1995) conducted in the barangays of Nueva Ecija, it was noted that the most commonly consumed protein items among residents in the farming communities are fish, crabs, freshwater shrimp, and to some degree, snails, and frogs. Price reported the market values for these edible aquatic organisms to range from 30 pesos to 120 pesos per kilogram. Farmers consider these items to be important sources of food that lessen their household expenses. Hence, the risks that pesticides pose to the deterioration of aquatic life and the consequent impact on humans as they consume fish and other species are worth exploring.

Birds/Avian Species

Concerns about the impacts of pesticides on birds virtually put environmental studies in the forefront of research priorities. Bird kills were initially attributed to the use of the pesticide DDT (later on was banned for use in most countries). These kills warranted an in-depth investigation, which was propelled into the limelight by Rachel Carson's Silent Spring (1962). While it is true that farmers in general value birds as pests (particularly to their rice crops), the abundance of birds in the farm areas and their contribution to the overall ecology make birds worthy for inclusion in the analysis.

Certain kinds of birds are also valued as food items. The average market value for any four medium-sized birds was noted to be around 60 pesos per kilogram (Price, 1995). Some of the more common kinds of birds that abound in the area include: *mangubong, uwis, tikling, kanduro, kasudlod,* and *pakubong*, among others.

Birds are in danger of pesticide exposure from direct contact, through the air, water, or through feed items such as soil organisms or grains. There have been several documented cases of bird kills due to monocrotophos- one of the most widely used insecticides in vegetable crops, particularly in onions. In the United States, an unreported number of dead robins were observed on perimeters of potato fields sprayed with this insecticide (US Department of Interior, 1993). In fact, the effectiveness of monocrotophos in killing birds is attested by its illegal use as a bird poison. Further investigation on the hazards posed by specific pesticide active ingredients to avian species is provided in this study.

Farm Animals

Farm animals such as carabao-- the local water buffalo--, and livestock such as goats, cows, and pigs are commonly found in the farm areas. For farmers, the carabao is arguably the single most important animal among those mentioned, mainly because they serve as draft animals. They are especially helpful during land preparation as most of the farms are small and not mechanized. Raising livestock is important in farming communities, as it is a secondary source (next to growing crops) of livelihood for farmers.

The "farm animals" category in this study refers only to the animals under class mammalia[10]; although, ducks, chickens, geese, and the like are also present on the farms. The reason for this restriction to mammals is that there are only a few toxicological studies specifically completed for other species, and therefore it would be difficult to include them in the evaluation. In contrast, an abundance of toxicological studies exist on lethality of farm chemicals to small mammals, which are mainly used to infer impacts of pesticides on human health.

STEP 2. Evaluating the Level of Pesticide Impacts on Human Health, Mammalian Farm Animals, Birds, Beneficial Insects, and Aquatic Species

Assessment of pesticide impacts is a crucial step towards evaluating the effectiveness of the IPM-CRSP in terms of controlling pests in an optimal manner. The severity of the health and environmental consequences of current pest control practices in the region (Nueva Ecija) are evaluated based on the extent of pesticide impacts measured using toxicity and exposure ratings. Changes in pesticide use patterns and consequent improvements in the level of environmental impacts accorded by the IPM-CRSP technologies would provide a measure of the benefits of the IPM program. The challenge is to come up with the most appropriate impact assessment scheme given the complexities and limitations of the data.

This section describes the process of rating the impacts of pesticides on the five impact categories discussed previously.

Introduction

Pesticides are used in agriculture for their virulent effects on weeds, insects, diseases, nematodes, and vertebrates. Unfortunately, the noxious effects of pesticides are not limited to these target pests and diseases, as risks inevitably extend to human beings and other organisms. The extent and nature of the adverse impacts of these agricultural pesticides on the environment, including non-target species and human beings, vary to a great degree depending on their inherent chemical properties and the manner in which these chemicals are incorporated into the environment. The hazards or risks caused by pesticides on different organisms can be at one end very minimal or at the other,

[10] Class mammalia refers to the highest class of vertebrata comprising man and all other animals with the following characteristics-- nourish their young with milk, have the skin usually more or less covered with hair, have mammary glands, among others (Webster's Third New International Dictionary).

extremely harmful. Approximating this level of impacts (or degree of hazards and risks) along this broad spectrum, is the focus of discussion in this section.

In the past, pesticide impact assessment simply involved projection of risks based on the quantity of pesticide used, that is the amount of active ingredient applied or application rates. While this made the process of risk assessment relatively simple, omission of factors such as the heterogeneity in pesticide qualities rendered the analysis incomplete. For example, some highly potent pesticides are applied only in minute amounts precisely because of their high efficacy and dangerously toxic effects. By ignoring the toxicity level and probability of exposure in the analysis, risks are inadequately quantified.

The interplay of various factors concerning pesticide toxicity, mobility, and persistence, together with the degree of exposure of organisms to the chemicals dictates the degree of pesticide impacts. Climatic conditions, soil properties, topography, and many other site-specific factors also influence pesticide behavior, consequently affecting risk and hazard levels. An ideal environmental assessment scheme or model must be able to incorporate all field-specific conditions, physical properties of each pesticide and subsequent behavior in the environment, and closely approximate the degree of exposure of each environmental category to the toxic substance. Hence, the analytical task of pesticide impact assessment can be quite complex, considering the amount and nature of information needed to make the analysis both comprehensive and reliable. The task is even made more difficult by data gaps, inconsistencies in laboratory experiments on pesticide toxicity, and the lack of studies that attempt to closely approximate actual field conditions (Levitan, 1997, Becker et al., 1989, Kovach et al., 1992, Mullen et al., 1997). The effects of agronomic and climatic conditions including compounding impacts of combining different kinds of pesticides, are difficult to replicate in field or laboratory experiments. Furthermore, the large number of pesticide classes, the different modes of pesticide activity affecting the environment, and the disparities and incompatibilities in information concerning pesticide impacts that must be consolidated to derive a reliable assessment of impacts, make this task all the more daunting.

Nonetheless, all things considered it is still imperative that an assessment of pesticide impacts be completed. Knowledge of the severity of effects that current chemical pest control practices cause, can guide IPM research and extension priorities. Hopefully, efforts to change pesticide use patterns for the better - by use of less chemicals, adoption of alternative pest control practices, and reduction in the use and manufacture of highly toxic chemicals – are encouraged. More importantly, providing farmers with better choices and a broader understanding of the consequences of their use of chemicals can further promote adoption of integrated pest management. The next section describes in detail, the impact assessment scheme adopted in this study.

Pesticide Impacts Rating Scheme

The process of rating pesticides consists of several steps that require both rule-based decision-making and judgement calls. The procedure and some of the more important issues in rating pesticide impacts are described in the succeeding section.

<u>Defining the Basis for Rating Pesticide Impacts</u>

It is important to define the basis for rating the pesticides (based on risks, hazards, or both). Some of the literature on pesticide impact assessment draws a distinction between hazards and risks. Yet there remains some confusion about these terms because they are often used interchangeably. Hazard assessment usually refers to evaluation of the potential of a substance to cause adverse impacts on ecosystems by making assessments on both the degree of exposure and its effects. This assessment is commonly done by comparing exposure levels with some toxicological endpoints referring to acute or long term effects, such as LD_{50}, LC_{50}, GUS, and so forth (Calamari and Di Guardo, 1993; Gneiser, 1993). Risk assessment, on the other hand, involves estimation of the probability that a substance causes an adverse effect on ecosystems for a specific scenario (Gneiser, 1993). Levitan (1997) describes "hazard" as a term that embodies a type of harm (for example lethal or sub-lethal hazard), and "risk" as a term that embodies a probability of harm. Hornsby et al. (1996) measured or operationalized risk as the product of hazard (a measure of toxicity) and the degree of exposure to the chemical.

The more general term "impacts" is used in this study. The level or degree of pesticide impacts is rated by combining a numeric index of toxicity (sometimes referred to as hazards) based on toxicological (and ecotoxicological) thresholds, with potential exposure levels.

<u>Deciding on a Common Basis for Classifying Pesticides</u>

The purpose of this step is to account for the heterogeneity in pesticide qualities. Inherent differences in the quality of pesticides with respect to toxicity, mobility, and persistence necessitate the use of a standardized reference for evaluating the severity of pesticide impacts on the environment and human health. Pesticides can be classified according to their technical components (active ingredients) or formulations.

Pesticide *common names* are generic names to refer to active ingredient compounds without naming the specific product or trade names. Chemical pesticides consist of an active ingredient, the actual poison, and a variety of additives, which improve the efficacy of its application and action. The technical components of pesticides used by farmers in the study area include: organochlorines, organophosphates, carbamates and pyrethroids.

The *formulation* of a pesticide is specific for a particular product and it is usually what distinguishes different brands and products containing the same active ingredient. Each pesticide formulation is characterized by a set of factors that determine how these chemicals affect different species of plant, animal, and human life. It is useful to account for the effects of different formulations on predicting pesticide behavior because of variations in efficacy and non-target impacts. The drawback to this approach is that almost all toxicological (and ecotoxicological) tests are active-ingredient based. Exceptions include, EPA data on toxicity to acute human health and some data that are only specific to the type of pesticide use (herbicide, insecticide, fungicide) and the type of environmental impact (effects on birds, or fish). To come up with a consistent manner in which to evaluate impacts of insecticides, herbicides, and fungicides across five environmental categories there is no other recourse but to classify the chemicals into their component active ingredients. This however does not seriously compromise the analysis because the longer term (meaning from weeks to months) environmental behavior of a pesticide is more likely be a function of the molecular properties of the active ingredient alone. Even though the initial behavior of a chemical in the environment is greatly affected by the formulation, as its molecules become isolated by dissipation from formulation constituents present at application, the active ingredient component persists (Hornsby et al., 1996).

Selecting the Indicators or Variables to Use in Measuring Pesticide Impacts

Evaluation of hazards and risks due to exposure of a given biological system to an environmental contaminant requires information on the nature of the contaminant (physico-chemical characteristics of the pesticides), biological activity, and its environmental distribution and fate (Bacci et al., 1993). There are a number of angles to consider with respect to information on pesticide characteristics and exposure potentials. Moreover, there are a multitude of impact assessments and ecotoxicological tests that incorporate various levels of specificity of data. For example, the analysis can include persistence of the pesticide, systemicity of the pesticide, the different routes of exposure of the organisms to the toxic chemicals, and even different test endpoints like lethal doses, vapor pressures, water solubility, and so forth. The challenge is to be able to sort through all the different angles and come up with a reasonable and consistent impact assessment scheme. The primary concern is determining the level of detail that goes in the analysis given available information.

Another issue to consider is the amount of site-specific conditions or variables to be included in the analysis. The available data on (eco-) toxicological endpoints are all based on tests conducted in temperate areas even though risks from pesticides may be greater in tropical climates because of social and biophysical factors such as higher temperatures, greater skin hydration (Levitan, 1997), and inadequate protection against exposure. Adjusting for site-specific conditions is ideal provided detailed information about field conditions is available to make it possible.

<u>Measuring the Degree of Pesticide Impacts: Scoring System</u>

Rating pesticides according to the severity of their impacts is a multi-dimensional or multi-attribute decision-making process that requires combining different indicators to produce a single degree or level of impact for each category. There are different ways in which to differentiate various levels of pesticide impact. The different levels of pesticide impacts can be classified using qualitative categories: low, moderate, or high, or using a numeric index: 1 to 5 (5 being the highest or gravest degree of impact). The numeric system is used in this study.

<u>Setting the Criteria for Evaluating the Level of Pesticide Impacts</u>

The level of pesticide impacts is determined by evaluating a set of criteria for each impact category. The criteria should reflect the fact that the effects of a chemical active ingredient on a particular species depend not only on its toxicity but also on the level of exposure. If the organism is not exposed to the active ingredient at any level that is considered hazardous, then the toxicity rating should be adjusted by weighting it with a coefficient reflective of the degree of exposure.

Degree of impact of a pesticide active ingredient on each of the five impact categories is therefore measured as the product of the toxicity ratings for each category and the degree of potential exposure of each species/category to the active ingredient. Toxicity ratings of a pesticide active ingredient to different species are evaluated using laboratory tests and some actual field observations conducted on a number of small animals, birds, aquatic species, arthropods and other non-target organisms. The degree of potential exposure of a particular species to an active ingredient is determined by evaluating the modes/routes by which the organism/species is likely to get exposed. These include, exposure through residues in food and in the environment (through groundwater contamination, surface water contamination, air pollution), mobility of the species and the frequency of chemical application (Table III.1).

The Criteria for Evaluating Pesticide Impacts

This section describes in detail the criteria for assessing 1) the toxicity or hazard levels of the active ingredient for each of the impact categories, and 2) the degree of potential exposure of each organism/species to the active ingredient.

<u>Human Health Impacts</u>

The effects of pesticides on human health can be either acute or chronic. Acute human effects result from a limited amount of exposure to an active ingredient while chronic human effects result from repeated low-level exposure to the active ingredient (Hallenbeck and Cunningham-Burns, 1985). The severity of these effects is influenced by factors like the time period over which exposure occurred, the kind and amount of active ingredient, and even the physical characteristics of the victim.

Hazard Levels:

The hazard level of an active ingredient based on human health impacts are evaluated using the following acute and chronic toxicity criteria.

1) Acute Effects

Assignment of hazard levels for this category are based on the World Health Organization (WHO) Recommended Classification of Pesticides by Hazard and/or the EPA Pesticide Classification System. The WHO hazard classification was designed to measure acute lethality of pesticide technical products (active ingredients) to human beings (Table III.2). The pesticide active ingredients are grouped into four categories based on acute toxicity of the active ingredient to rodents - normally used as surrogates for human beings. Acute toxicity is measured by: 1) oral LD_{50} , the orally ingested dose (mg. of toxicant per kg of body weight) of a pesticide which kills 50 percent of the test population animals; and 2) dermal LD_{50} , the dose of a pesticide applied to the skin which kills 50 percent of the test population animals. The LD_{50} thresholds are adjusted based on the type of pesticide formulation (solid or liquid) and on the type of tests conducted (oral or dermal tests). Results from dermal toxicity tests are given more weight since the predominant route of exposure in pesticide handling is through the skin rather than oral ingestion.

The U.S. Environmental Protection Agency (US EPA) classification system is reflected on the labels of all pesticide trade products. The EPA requires pesticide manufacturers to print cautionary or signal words associated with the level of toxicity of the active ingredient present in the formulation (Table III.3). The system is based on five human health indicators, acute lethality measured by oral LD_{50}, Dermal LD_{50}, and Inhalation LD_{50}, and two sublethal effects - eye and skin irritation.

A pesticide active ingredient is assigned a toxicity rating of 1) HIGH, if it is under hazard class Ia or Ib, and/or if labeled with a "Danger/Poison" signal word; 2) MODERATE, if it is under Hazard Class II and/or labeled with a "Warning"; and 3) LOW, if it is of Class III or IV and/or has a "Caution" signal word (Table III.4).

2. Chronic Effects

Chronic toxicity in humans is determined by testing for potential reproductive effects (ability to produce offsprings), teratogenic effects (deformities in unborn offspring), mutagenic effects (permanent changes in hereditary material such as genes and chromosomes), and oncogenic effects (tumor growth). The results of these tests are evaluated according to their weight of evidence (WOE)[11] or conclusiveness.

The results of each test are classified with respect to the following degree of conclusiveness (Mullen, 1995):

1) Negative
2) No Evidence
3) Inconclusive
4) Data Gap
5) Possible
6) Probable
7) Positive

The chronic toxicity rating of a specific pesticide active ingredient is then determined by counting all the evidence for chronic effects (Table III.5). Evidence for each of the chronic toxicity tests are gathered from various reports by the Environmental Protection Agency (Table III.6), the International Agency on Research for Cancer (IARC) (Carcinogenicity Classification System, Table III.7), and from the Extoxnet database (for oncogenic, mutagenic, teratogenic, and reproductive effects. Ratings from Mullen (1995), Becker (1989), and Kovach et al. (1992) are also used.

Human Exposure Levels:

Potential human exposure to the toxic substance (active ingredient) is measured by assessing the risk of contamination to different modes of human exposure. Humans can be exposed to the contaminants through residues in food and in the environment. There is a multitude of ways by which human exposure to toxic chemicals can be measured. Some of the indicators used to evaluate potential human exposure include: environmental fate measured by persistence or water solubility, soil adsorption, field half-life; intensity of exposure (measured by vapor pressures, amount of active ingredients, or production volumes); runoff risk; leaching potentials; drift potential; position of application, and so forth. However, it is difficult to gather all data necessary to incorporate all of these indicators. For this study, data availability and importance of

[11] Swanson, et al (1997) used the WOE classification assigned by EPA and or IARC (International Agency on Research for Cancer) to score chemical carcinogenicity.

the variables or relevance to the study site and field conditions were the basis for selecting the exposure indicators.

Indicators of Potential Exposure:

The indicators of potential exposure chosen for this study include:

1. Runoff Potential (Risks to Surface Water Quality)

Pesticides migrate to surface water primarily by agricultural runoff, either adsorped to soil particles or in solution. Spills, rainwater, and drift from aerial spraying are other common means for pesticides to enter surface water. Risk of surface water contamination is an important indicator of pesticide impacts because of the consequent risk to fish and other aquatic species that are considered part of the farm residents' usual diet. Further risks of exposure arise when the farmers invariably use the rivers, drainage canals, and other surface water areas to rinse off dirt from their skin and from their farm implements after working in the fields.

Ideally, risk of surface water contamination is evaluated using the following indicators: 1) runoff potential of field site (includes slope gradient, soil texture, slope length, soil surface conditions, crop cover, and distance to surface water); 2) drift potential = f (application technique, distance to surface water); 3) where pesticide is applied; and 4) field half-life (measured by DT_{50}, days).

Because of lack of field-specific data and the difficulty in simulating actual field conditions a more general method is adopted for this study that is based on the surface water matrix, shown in Table III.8 (Becker et al., 1989). Ratings from Becker et al. (1989) and Mullen (1995) are used for some of the active ingredients of concern, other sources of information include the EXTOXNET database and the Farm Chemicals Handbook (1997).

If runoff ratings are not available, 3 pesticide characteristics are evaluated independently using the following EPA red flag values:

1) water solubility > 30 ppm

2) soil adsorption (K_{oc}) > 300

3) soil half-life > 21 days

Then, surface water risk levels are assigned based on the number of red flags exceeded (Table III.9).

2. Leaching Potential (Risks to Groundwater Quality)

The severity of groundwater contamination is measured by the leaching potential of the pesticide active ingredient. As in the case of surface water, groundwater risk is also a function of soil properties, climatic conditions, and other site-specific farm practices and agronomic conditions. In the study area, the residents' main source of drinking water is the deep wells or artesian wells making groundwater contamination an important source of pesticide impacts on human health.

The rating system for groundwater risk is based on the pesticide leaching matrix (TableIII.10) (Becker et al., 1989). For those active ingredients not included in this matrix, Gustafson's groundwater ubiquity score (GUS) is used (Wauchope et al., 1992). GUS is defined in terms of soil half-life of the pesticide, $t_{1/2}^{soil}$ and pesticide's soil sorption index, K_{oc}. The formula used to calculate the GUS is as follows: $GUS = \log_{10}(t_{1/2}^{soil}) * (4 - \log_{10}(K_{oc}))$. Table III.11 shows how risk levels are assigned based on different groundwater ubiquity scores.

3. Risk of Air Contamination

Assessment of risk of air contamination is based on the Ipest Model developed by van der Werf and Zimmer (1997). Assessment is based on pesticide volatility, and place of application. Henry's Law Constant, a non-dimensional ratio of vapor pressure and water solubility is used as an indicator of pesticide volatility ($\log_{10} K_H$). Application of the pesticide by incorporation into the soil is considered to present less risk of air contamination than application to the soil surface or crop. A risk level of one is assigned to pesticides that are incorporated into the soil and risk level of 3 is assigned to pesticides that are applied to the soil surface or crop, and a risk level of 5 is assigned to pesticides that are based on foliar application to the whole field.

4. Potential exposure through Food Residues

Food residues in plants, particularly vegetables are important considerations in this study because farm residents generally grow their own vegetables for consumption. Plots for various vegetables are usually planted adjacent to onion plots. Consumption of onions and other vegetables that have been sprayed with insecticides, herbicides, and fungicides can therefore pose hazards to human health.

Potential for exposure through food residues is evaluated based on systemicity of the pesticide, whether pre- or post-emergent, and by plant surface residue half-life. Systemicity of a pesticide refers to its ability to be absorbed by plants. Pesticides that are effective due to incorporation into plants are considered systemic. Following the ratings from Kovach et al. (1992), all herbicides are given a value of 1 for systemic activity since herbicides are not normally directly applied to food crops. All post-emergent pesticides are assigned a value of 3 and pre-emergent herbicides are assigned a value of one, since plant surface persistence is only important for post-emergent herbicides and not pre-emergent herbicides. Finally, for plant surface residue half-life values, a risk rating of 1 is assigned if half-life is from 1-2 weeks, 3 if half-life is from 2-4 weeks, and 5 if half-life value is greater than 4 weeks.

Table III.1.A. Toxicity Indicators by Environmental Category

CATEGORY	INDICATORS	DEFINITION
Human Health		
Acute Toxicity	Oral LD_{50} (mg/kg)	The orally ingested dose (number of mg of toxicant per kg of body weight) required to kill 50% of a large population of test animals
	Dermal LD_{50} (mg/kg)	The dose of a pesticide applied to the skin which kills 50% of the test population animals
	Inhalation LC_{50}	The concentration of a pesticide in air over a pre-determines period of time that kills 50% of the test population animals
Chronic Toxicity	Weight of Evidence of:	Weight of evidence of test results are classified with respect to the following levels: negative; no evidence; inconclusive, data gap, possible, probable, positive
	Carcinogenicity	The ability of the toxic substance to encourage the growth of cancer
	Teratogenicity	The ability of the toxic substance to cause deformities in unborn offsprings
	Mutagenicity	The ability of the toxic substance to cause permanent changes in hereditary material such as genes and chromosomes
	Other tests	Potential reproductive effects; Impacts on human organs; Sub-lethal effects
Aquatic Species	95-hr LC_{50} (mg/L)	The concentration of active ingredient that kills half of the test population within 95 hours;
Beneficial Insects	Beneficial Effects Score	The score is based on the EIQ developed by Kovach et al.; scores reflect risk of pesticides to beneficial arthropods
	Insect Toxicity	Ratings from past studies and toxicity databases
Birds	8-day LC_{50}	The concentration of active ingredient that kills half of the test bird population within 8 days
	Bird Toxicity Ratings	Ratings from past studies and toxicity databases

Table III.1.B. Exposure Indicators by Environmental Category

CATEGORY	INDICATORS	DEFINITION
Human Health		
Leaching Potential	Groundwater Ubiquity Score	GUS is defined in terms of soil half-life and the pesticide's soil sorption index: GUS = log10(t1/2 soil) * 4-log10(Koc)
	Leaching Potential Score	The score is determined using the Pesticide Leaching Matrix developed by Becker et al. to evaluate pesticide risks to groundwater (high, moderate, low)
Runoff Potential	Water Solubility	The ability of a substance to dissolve in water;
	Soil Adsorption; Koc	It is a measure of the tendency of pesticides to attach to soil particle surfaces
	Soil ½-Life (# of days)	The time required for pesticides in soil to degrade to one-half of the previous concentration; The longer the ½-life, the greater the potential for pesticide movement
	Surface Loss Potential	Risks to surfacewater is evaluated according to high, moderate, or low based on the Surfacewater Matrix
Air Contamination	Henry's Law Constant	A non-dimensional ratio of vapor pressure and water solubility; used as an indicator of pesticide volatility
	Place of Application	Refers to the manner in which the pesticide is applied; whether the pesticide is incorporated into the soil; applied on the soil surface; or to the crop
Food Residues	Systemicity	Measure's pesticide's ability to be absorbed by plants
	Time of Application	Based on whether the pesticide is pre- or post-emergent
Aquatic Species	Runoff Potential Score	The potential for exposure depends on the likelihood that pesticide toxins reach surfacewaters
Beneficial Insects	Plant Surface Residue ½-life	Measures persistence of the toxic substance in the crops; expressed in days

Table III.2. Criteria Matrix for WHO Classification of Pesticides by Acute Hazards

Hazard Indicators		WHO Hazard Categories				
		Extremely Hazardous Ia	Highly Hazardous Ib	Moderately Hazardous II	Slightly Hazardous III	Unlikely to be Hazardous IV
Oral LD_{50} (mg/kg)	Solid	≤ 5	5 – 50	50 – 500	> 500	≥ 2000
	Liquid	≤ 20	20 – 200	200 – 2000	> 2000	≥ 3000
Dermal LD_{50} (mg/kg)	Solid	≤ 10	10 – 100	100 – 1000	> 1000	Not given
	Liquid	≤ 40	40 – 400	400 – 4000	> 4000	Not given

Source: The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1996-1997.

Table III.3. Criteria Matrix for U.S. EPA Classification of Pesticides by Acute Human Health Hazards.

Hazard Indicators	EPA Toxicity Categories and Pesticide Label Signal Words			
	"Danger" I	"Warning" II	"Caution" III	"Caution" IV
Oral LD_{50} (mg/kg)	≤ 50*	50 – 500	500 – 5000	> 5000
Inhalation LC (mg/L)	≤ 0.2*	0.2 – 2	2 – 20	> 20
Dermal LD_{50} (mg/kg)	≤ 200*	200 – 2000	2000 – 20,000	> 20,000
Eyse Effects	Corrosive corneal opacity not reversible w/in 7 days	Corneal opacity reversible w/in 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

* Label must also say "Poison" and display skull and crossbones.
Source: Farm Chemicals Handbook 1996

Table III.4. Assignment of Acute Human Health Toxicity Ratings Based on the WHO and the EPA Pesticide Classification Schemes

WHO Hazard Class	EPA Signal Word	Toxicity Level
Ia or Ib	Danger or Danger/Poison	High
II	Warning	Moderate
III or IV	Caution	Low

Table III.5. Assignment of Risk Levels for Human Chronic Toxicity

Indicator/Classification of Test Results	Risk Levels
Existence of one or more positive test results or conclusive evidence of teratogenicity, carcinogenicity, or mutagenicity	High
Data gaps, Possible, Probable evidence of teratogenicity, carcinogenicity, or mutagenicity	Moderate
Existence of negative test results, inconclusive results, or no evidence of teratogenicity, carcinogenicity, or mutagenicity	Low

Table III.6. EPA Classification of Chemicals According to the Weight of Evidence (WOE) from Epidemiologic and Animal Studies.

GROUP	WOE of CARCINOGENICITY	CLASSIFICATION
A	Sufficient evidence in humans	Human carcinogen
B1	Limited evidence in humans	Probable human carcinogen
B2	Sufficient evidence in animals with inadequate or lack of evidence in humans	
C	Limited evidence in animals and inadequate or lack of human data	Possible human carcinogen
D	Inadequate or no evidence	Not classifiable as human carcinogen
E	No evidence in adequate studies	Not a human carcinogen

Table III.7. The IARC Carcinogenicity Classification System.

GROUP	CLASSIFICATION
1	Carcinogenic to Humans
2A	Probably Carcinogenic to Humans
2B	Possibly Carcinogenic to Humans
3	Not Classifiable as to human carcinogenicity
4	Probably not Carcinogenic to Humans

Table III.8. Assignment of Surface Water Risk to an active ingredient based on Surface Water Matrix developed by USDA-SCS

Soil Surface Loss Rating	Pesticide Surface Loss Ratings		
	Large	Medium	Small
High	High	High	Moderate
Intermediate	High	Moderate	Low
Nominal	Moderate	Low	Low

Source: Becker et al., 1989.

Table III.9. Surface Water Risk Levels using Pesticide Characteristics.

Number of Red Flags	Risk Levels
2 or more red flags exceeded	High
1 red flag exceeded	Moderate
No red flag exceeded	Low

Table III.10. Assigning Groundwater Risk Levels based on the Pesticide Leaching Matrix

SOIL LEACHING RATING	PESTICIDE LEACHING RATINGS		
	Large	Medium	Small
High	High	High	Moderate
Intermediate	High	Moderate	Low
Nominal	Moderate	Low	Low

Table III.11. Assignment of Risk Levels based on the Groundwater Ubiquity Score.

CLASSIFICATION	GROUNDWATER UBIQUITY SCORE (GUS)	RISK LEVEL
Leachers	GUS > 2.8	High
Transitiona1	.8 < GUS < 2.8	Moderate
Non-Leachers	GUS < 1.8	Low

Impacts on Aquatic Species

Fish LC_{50} data are used to rate toxicity of pesticides on aquatic species. Fish LC_{50} refers to the concentration of a chemical in water that causes death in 50% of the fish tested in a 96-hour test. Some studies distinguish between chronic and acute fish toxicity using LC50 values to measure acute effects and Fish NOEL[12] (No-observable-effect-level) to score chronic sublethal effects on fish (Swanson, et al., 1996). LC50 data are available for different fish and other aquatic species. Toxicity data on fathead minnow, freshwater fish, algae, daphnia, and some shellfish are usually available. The hazard score for fish and other aquatic species category is determined by the highest level of risk a pesticide poses to any of the aquatic species or by the most sensitive.

The aquatic species risk level is weighted by the surface water risk levels (measure of potential exposure), since a pesticide can not cause any risk to aquatic species if the chemical does not reach surface waters. Criteria is provided in Table III.12.

Table III.12. Assignment of Hazard Levels to Aquatic Organisms based on Different Toxicological Endpoints

96-hr LC50 VALUES (parts per million)	HAZARD LEVEL
>10 ppm	Low
1-10 ppm	Moderate
< 1 ppm	High

Ratings from Kovach et al. (1992), Mullen (1995), and Becker et al. (1989) are used, and for pesticides not rated by any of the above, the EXTOXNET database is used

Effects on Birds

The 8-day LC_{50} endpoint is used to rate toxicity to birds. Toxicity ratings are assigned as follows: LC50 of greater than 1,000 parts per million is assigned a LOW rating, 100-1,000 parts per million of LC50 is assigned a MODERATE rating, and LC50 values of 1-100 ppm are assigned a HIGH rating.

Following the Kovach et al. (1992) method, bird exposure ratings are based on the pesticide half-life in soil and on plant surfaces since birds find their food both on the ground and in soil.

[12] The highest dosage administered that does not produce observable toxic effects, estimated from LC_{50} data.

Effects on Beneficial Insects

The rules for rating toxicity to beneficial insects are as follows:

1. if a report says that an active ingredient is "highly" or "extremely" toxic to any arthropod species a HIGH level of risk is assigned to that pesticide
2. if the active ingredient is reported to be moderately toxic, a MODERATE level of risk is assigned
3. if no report identifies the active ingredient to pose a high or moderate level of risk, it is assigned LOW level of risk

The assumption is made that the toxicity effects of the different active ingredients on different beneficial arthropods are the same. Toxicological tests are conducted on specific types of arthropods; however the beneficial arthropods' risk scores are evaluated using toxicity reports that are not necessarily insect-specific. Exposure level is set using the plant surface reside half-life values. Using the EIQ values, the rating scheme is provided in Table III.13.

Table III.13. Assignment of Risks to Beneficial Arthropods using EIQ scores

Beneficial Effects Score (BENE) from EIQ	RATING
BENE > 50	High
25 < BENE ≤ 50	Moderate
BENE ≤ 25	Low

Source: Mullen (1997).

References for the ratings include: Mullen (1997), EXTOXNET, Smith (1993), Higley and Wintersteen (1992), Kovach et al. (1992), USEPA, and Hartley and Kidd (1987).

Effects on Mammalian Farm Animals

Criteria for both hazards and exposure are exactly the same as those developed for human health effects. This is because toxicity tests are all based on small mammals and since routes of exposure are similar impact levels for human health and mammalian farm animals are identical.

The Environmental Impact Scoring System

The pesticide impact scoring scheme is summarized in Table III.14. The scores assigned to each pesticide active ingredient (by impact category) are combined with usage data to come up with an ecological rating score. The formula is as follows: ECORATING SCOREij = (ISCORE)ij * (% A.I.)i * (RATE)i; where ISCORE refers to the impact (risk) score derived using the scheme described above; % AI refers to the percentage of active ingredient in the formulation; RATE refers to use rates or application rates in dose/hectare. The index i refers to the active ingredient and j denotes the 5 different impact categories. These scores are derived for 2 scenarios: with IPM CRSP adoption and without IPM CRSP adoption. The difference represents the amount of risk avoided induced by the program.

Table III.14 Pesticide Impacts Scoring System

IMPACTS	INDICATORS	SCORE		
		HIGH RISK = 5	MODERATE RISK = 3	LOW RISK = 1
Human Health				
Toxicity				
Acute Toxicity	Pesticide Class (WHO Criteria)	Ia; Ib	II	III
	Signal Word (EPA Criteria)	Danger/Poison	Warning	Caution
Chronic Toxicity	Weight of Evidence of Chronic Effects	>1 Positive Conclusive Evidence	Data Gap Possible Probable	Negative Inconclusive Evidence
Exposure				
Leaching Potential	Groundwater Ubiquity Score	GUS > 2.8	.8 > GUS > 2.8	GUS < 1.8
	Leaching Potential Score	High	Moderate	Low
Runoff Potential	No.of Red Flags Exceeded for the ffg:	> 2 red flags	1 red flag	0 red flag
	Soil Adsorption (Koc) > 300			
	Soil 1/2-life > 21 days			
	Water Solubility > 30 ppm			
	Surface Loss Potential	High	Moderate	Low
Air Contamination	Henry's Law Constant			
	Place of Application	Aerial	Crop/Soil Surface	Soil
Food Residues	Systemicity		Systemic	Non-systemic
	Time of Application		Post-emergent	Pre-emergent
	Plant Surface Residue Half-life	> 4 weeks	2 - 4 weeks	1 -2 weeks
Aquatic Species				
Toxicity	95 hr LC50 (fish) mg/L			
	Fish/Other Aquatic Species Toxicity	> 10 ppm	1-10 ppm	<1 ppm
Exposure	Runoff Potential Score	High	Moderate	Low
Beneficial Insects				
Toxicity	Beneficial Effects Score (BENE)	BENE > 50	25 < BENE < 50	BENE < 25
	Insect Toxicity Ratings	Extreme/High	Moderate	LOW (1)
Exposure	Plant Surface Residue Half-life	> 4 weeks	2 - 4 weeks	1 -2 weeks
Mammalian Farm Animals	(same as human health)			
Birds				
Toxicity	Bird toxicity ratings	High/Extreme	Moderate	Low
	8 day LC50	1 - 100 ppm	100 - 1000 ppm	> 1000 ppm
Exposure	Soil Half-life	> 100 days	30 - 100 days	< 30 days
	Plant Surface Half-life	> 4 weeks	2 - 4 weeks	1 -2 weeks

Step 3. Measuring the Rate of Adoption of the IPM CRSP Technologies

Adoption is an important factor in measuring the success of a program like integrated pest management. The accomplishments of its goals such as achieving optimal pest control, improving the quality of the environment, and reducing human health risks depend primarily on producers' acceptance of the proposed alternatives to managing the pests. The demand for such alternatives must exist or must be created before technology transfer is allowed and before program benefits are accrued. With this realization, the IPM Collaborative Research Support Program adopted a strategy that identified farmers in each of the sites world-wide as major collaborators in the development of the IPM program. Mindful of the fact that farmers had a major role in defining the success of the program, emphasis was placed on farmers' participation on activities all the way from planning to implementation. In line with this, most of the scientific experiments were carried out in vegetable fields of farmer-collaborators. Currently, these demonstration plots serve to showcase the effectiveness and viability of different IPM strategies in the hope that the adoption process is accelerated.

The adoption literature is inundated with studies that identify different socio-economic factors associated with producers' technology adoption decisions and evaluate the explanatory power of these factors in predicting adoption (Bultena and Hoiberg, 1983; Kovach and Tette, 1988; Harper et al., 1990; McNamara et al., 1991; Fernandez-Cornejo et al., 1994). Empirical studies show that a host of socio-economic factors including: 1) farmer characteristics like age, farming experience, education, wealth; 2) farm structure such as farm size, crop diversity, soil types and other locational attributes; as well as, 3) variables that measure producers' risk aversion, management skills, and institutional linkages, have significant influence on adoption of agricultural technologies and innovations.

IPM adoption can be operationalized in various ways depending on whether IPM refers to a single practice or a collection of different cultural, biological, and/or chemical practices (Nowak,, 1987[13]; Thomas et al., 1990. The most common single-practice IPM adoption studies look at adoption of scouting. Scouting consists of the use of professional

[13] Nowak defined adoption as an index of conservation practices; he also examined adoption of a single practice--use of conservation tillage.

scouting services, passive monitoring devices such as pheromone traps, sticky boards, and so forth and/or sweep nets (Fernandez-Cornejo et al., 1994; Harper et al., 1990; McNamara et al., 1991). Some of these studies also examined scouting in conjunction with threshold level decision rules in applying pesticides. Distinction among different levels of adoption has also been addressed in a few studies (Mullen et al., 1997; Fernandez-Cornejo et al., 1994; Kovach and Tette, 1988). Various typologies have been used ranging from adopters versus non-adopters to none, low-, mid-, or high IPM users. USDA classified different levels of IPM adoption based on a continuum of practices from simple chemical applications and cultural alternatives to the more advanced bio-intensive techniques. These levels are sometimes differentiated using the number of practices employed or the proportion of acreage under 'IPM'.

This study focuses on adoption of five different IPM CRSP practices: 1) use of castor as a trap plant; 2) rice hull burning; 3) use of microbial agents (i.e. Bt and NPV); 4) reduced insecticide-use strategy; and 5) alternative herbicide use strategy. Adoption of each of these technologies is predicted independently using econometric procedures and the onion growers are classified simply as either adopters or non-adopters depending on their predicted probabilities of adoption for each technology.

There is also a rich literature on the issue of diffusion of agricultural technologies (Fernandez-Cornejo, 1994; Feder, 1985; Rogers, 1983). The diffusion process is characterized by an S-shaped curve. The process goes as follows: after a slow start with only a few farmers adopting the innovation, adoption eventually picks up at an increasing time rate; then, and as the number of adopters grows relative to the non-adopters, the rate of increase ultimately slows down and adoption asymptotically approaches its maximum level until the process ends (Rogers, 1983).

Measuring the degree of technology adoption at a particular moment in time however is not a very common undertaking. In the United States, efforts to develop new tools to distinguish between various levels of IPM adoption and measure the percentage of acreage under IPM are just underway[14].

[14] This effort was precipitated by the U.S. government's goal to have 75 percent of cultivated acreage under IPM by the year 2000 and by the search for methods to support 'green labelling' for agricultural produce (Benbrook and Groth, 1996).

The evaluation of technology impacts or IPM program benefits can not be accomplished without a measure of the degree of adoption of the alternative technologies. This becomes more difficult when the program is still in its initial stages with almost none to very few adopters, adoption rates in this case are assumed, inferred, or predicted. In the study area, awareness about vegetable IPM is very minimal but growing. The survey indicated that only 28 percent of the farmers interviewed in the study sites have heard of IPM and only 17 percent have attended any IPM training.

The task at hand is to predict the percentage of IPM CRSP technology adoption within the IPM CRSP sites and project the spread to neighboring areas (San Jose area).

Econometric estimation is used to meet two specific objectives: 1) to predict the probability of adoption of five IPM CRSP technologies given a set of socio-economic and environmental factors and estimate the proportion of farmers who will likely adopt each technology; and 2) to identify factors that significantly affect adoption of each technology and make recommendations for intervention.

The Model

The theoretical context for analysis of the type of discrete, binary choice problem embodied in selection of pest management technology is given by McFadden's Random Utility Model. The assumption is made that producers (consumers of technology) are rational. They make choices that maximize their perceived utility subject to various constraints. This maximization however is subject to errors of imperfect perception and optimization, including measurement errors associated with the causal variables. Hence, the model assumes that utility is a random function.

The true (but latent) dependent variable of interest is the utility the decision-maker realizes from the decision to adopt the technology. Since individual's utility is not observed, it is inferred from stated preferences or adoption choices, such that the utility from the option elected is greater than the utility gained from the alternative (Maddala, 1983).

The decision maker's unobserved net gain in utility of adopting practice j, denoted by U^*_j is the difference between an individual's utility from deciding to adopt the technology and utility from not adopting the technology. This net gain can be interpreted as being explained by the variables X_j that would have explained utility levels with adoption or without adoption, plus the disturbance term ε, such that:

$$U^*_j = U_{adoption} - U_{non\text{-}adoption}$$
$$= X_j\beta_j + \varepsilon_j$$

Since only the decision whether or not to adopt is observed, it can be inferred that

$$Y_j = \begin{cases} 1 \text{ if } U_j^* - \varepsilon_j \geq X_j\beta_j \\ 0 \text{ if } U_j^* - \varepsilon_j < X_j\beta_j \end{cases}$$

where Y_j is a binary variable representing adoption of practice j and X_j is a vector of regressors relevant in explaining adoption.

Technology adoption in this case is modelled using a qualitative dependent variable and is represented by a dummy variable. Estimating binary choice models that deal with the probability of explaining whether or not an individual adopts a technology or not is usually mired with special problems. When the dummy dependent variable is set up such that it takes on a value of either 0 or 1 and is regressed on a set of explanatory variables, the predicted values of the dependent variable is expected to fall within the [0,1] range. However, it is quite possible to have estimated probabilities outside this range (Kennedy, 1992). The logistic and the cumulative normal functions can be used to squeeze all the estimated probabilities to lie within the [0,1] range. The logistic function creates the LOGIT model and the cumulative normal function creates the PROBIT model. There are practical reasons for favoring one or the other, in some cases for mathematical convenience, but it is difficult to justify the choice of one distribution or another on theoretical grounds (Greene, 1993). The logit model is used for this study.

The logistic function is given as $f(\theta) = e^{\theta}/(1 + e^{\theta})$ and it varies from 0 to 1 as θ varies from $-\infty$ to $+\infty$. θ represents $X\beta$, a linear function of several characteristics that are assumed to explain the dependent variable. The logistic model specifies that the probability of adoption is given by: $P(Y=1) = e^{x\beta} / (1 + e^{x\beta})$; consequently, the probability of non-adoption is: $P(Y=0) = 1 - P(Y=1) = 1/ (1 + e^{x\beta})$. The logit model is estimated using maximum likelihood techniques.

The likelihood function is formed as: $L = \pi_i (e^{xi\beta} / (1 + e^{xi\beta}))\ \pi_j (1/(1+e^{xj\beta}))$; the subscript i denotes adopters and j denotes non-adopters. This likelihood function is maximized with respect to β (using an iterative procedure, usually Raphson-Newton) to get the maximum likelihood estimates of β (β^{MLE}). The chosen regressors or elements of X are described in the next section.

The Regressors

The explanatory variables used in the logit analysis are classified according to the following general categories: 1) farmer characteristics; 2) managerial factors; 3) farm structure; 4) physical/locational factor; 5) information/institutional factors; and 6) awareness /perceptions regarding pesticide impacts. Variable names, definitions, and summary statistics are provided in Table III.15. The next section discusses various hypotheses regarding the causal variables.

Farmer Characteristics

Empirical studies provide evidence that age, educational attainment, and farming experience significantly influence technology adoption. It is postulated that younger farmers are more open to new ideas and innovations, while those who are older and have more farming experience tend to be set in their ways and less receptive to innovations. Both the AGE and EXPERIENCE variables are therefore hypothesized to have a negative effect on adoption of the IPM CRSP technologies. Educational attainment on the other hand, is expected to have a positive relationship with adoption since more educated farmers are generally better informed and cognizant of environmental and health risks.

In studies dealing with adoption of conservation practices, tenure security is usually predicted to have a positive effect on adoption. The rationale behind this argument is that farmers who own the land they till care more about the long term sustainability (and productivity) of agricultural production in their lands and therefore have more incentives to invest on the land (Ervin, 1986; Nowak and Korsching, 1983). Because it can be argued that IPM is not directly related to land conservation, although conservation is one of the consequences of practicing IPM, the TENURE variable in this study is viewed differently-- as a proxy for the ability to diversify and spread out risks as owner operators have more decision-making power. Hence, it is expected to have a positive sign.

Managerial Factors

OFFWORK indicates whether the producer is a full-time farmer or is employed in off-farm work. This variable is expected to capture the income effect associated with the additional income generated from off-farm sources. The hypothesis is that having other sources of income minimizes the financial risks associated with trying out new practices (Hoover and Wiitala, 1980; Taylor and Miller, 1978). It could also be argued that part-time farmers may not have the extra time to devote to learning new practices and may be discouraged to adopt. FHOURS is used to capture this element. It is defined as the time spent working on the farm per week. Finally, the PCTCOST variable is calculated as the ratio of pesticide expenses to the total operating expenses for one cropping season. This ratio reflects the importance of pesticides in the overall mix of inputs. Producers who rely more on pesticides for solutions to their pest problem may be more reluctant to adopt alternative practices.

Farm Structure

FSIZE represents the scale of the farm operations. Large-scale operators should have more flexibility in experimenting with new technologies as they have more land to allocate for experiments. FSIZE can also proxy for wealth. FSIZE is expected to positively influence adoption. PSHARE represents the share of onion profits in total net farm income. It measures producers' dependence on onion farming for income. Those who are mostly dependent on onion production for their livelihood may be more concerned about their short run economic survival. Hence, these basic concerns usually outweigh concerns about the environment and human health. They may be more risk-averse and less inclined to try new and unfamiliar practices.

It is more common in adoption studies to use farm income as an indicator of wealth and scale of operations. To get a meaningful measure of this however, income data should represent average values generated over at least three years of operation. Single-season data will not be reliable as income can be affected by unusual climatic or economic distortions at any given year.

Physical/ Locational Factor

IPM CRSP activities are conducted in different sites in San Jose. The presence of technology demonstration sites should increase awareness about the benefits of the technologies in those areas and therefore should increase the probability of adoption among targeted farmers. Dummy variables for San Jose, Bongabon, and Munoz are created to capture the area or regional differences in the model, including farmer attributes.

Institutional/Informational Factors

Availability and characteristics of informational networks, the extent and nature of contacts with "change" agents, and the position and credibility of these agents in the local community can all influence the farmer in the adoption decision (Lionberger and Gwin, 1982). The information factor is analyzed using the different sources of pest management advice available in the region. These include: fellow farmers (SPCF), DA-technicians (SPCDA), cooperatives (SPCCOOP), pesticide agents (SPCAGENT), or training courses (SPCTRAIN). The influence on IPM adoption of farmers' contact with pesticide sales agents is expected to be negative. With respect to the other information sources, no prior expectations about their signs are offered.

Farmers attend training courses organized by different interest groups. Since the survey instrument did not distinguish among different kinds of training courses, the parameter coefficient of SPCTRAIN could take any sign depending on the nature of the training; nevertheless, training/education may prove to be an effective mode of intervention.

Farmers' awareness of different pest management practices either through formal training (ATTEND) or through informal sources (HEARD) are also included under this category. As farmers become more acquainted with IPM concepts and more aware of their benefits, the likelihood of IPM adoption is increased.

Experiences/Attitudes about the Health and Environmental Impacts of Pesticides

The PREVENT variable is an index of the level of care a farmer takes to avoid the hazards from pesticide exposure. A higher number of preventive measures employed implies a higher premium placed on human health effects of pesticide use; this makes the individual more likely to adopt IPM practices. The variable is a scale from one to five, created by adding up the number of preventive measures employed by each individual, which includes: 1) wearing a face mask; 2) long pants; 3) long-sleeved shirts; 4) shoes when spraying pesticides, and 5) boiling drinking water (usually obtained from the well).

SICK indicates whether the farmer ever experienced being sick after spraying pesticides or not and OBSENV indicates if the farmer had observed any of the environmental consequences of pesticide use such as animal poisoning, fish kills, bird kills, and pest resurgence) in the past. Producers with either experience are hypothesized to be more receptive to safer alternatives to pesticides.

Table III.15. Summary Statistics and Definitions of the Regressors

VARIABLE	DEFINITION/UNIT	Mean[a]	σ	Expected Sign]
FARMER CHARACTERISTICS				
Age	No of years	46	12.6	-
Educational Attainment (EDUC)	No of years	8	3	+
Farming Experience (EXPER)	No of years in onion farming	19	12.6	---
Tenure Status (OWNER)	1 = owner-operator 0 = otherwise	0.58	0.5	+
MANAGERIAL FACTORS				
Farm Hours (FHOURS)	Time spent on farm per week; number of hours	21	16.2	-
Off-Farm Work (OFFWORK)	1 = farmer has off-farm employment 0 = otherwise	0.51	0.5	+
Pesticide Costs (PCTCOST)	Ratio of pesticide expenses to total operating costs; percent	0.14	0.09	-
FARM STRUCTURE				
Farm Size (FSIZE)	No of hectares	1.55	1.5	+
Onion Profit Share (PSHARE)	Ratio of profits from onion to total farm income; percent	0.3	0.32	-
PHYSICAL/LOCATIONAL FACTOR				
Site Dummies	1 = farm is located in that site; 0 = otherwise;			
▪ *San Jose*		0.62	0.48	+
▪ *Munoz*[b] *(MUNOZ)*		0.2	0.42	+
▪ *Bongabon (BONGA)*		0.15	0.36	---

Table III.15 continued…

VARIABLE	DEFINITION/UNIT	Mean[a]	σ	Expected Sign
INSTITUTIONAL/INFORMATIONAL FACTORS				
Source of Pest Control Advice:	1= farmer obtained pest control advice from the specified source; 0 = otherwise;			
Farmer (SPCF)		0.70	0.46	---
Dept. of Agriculture (SPCDA)		0.14	0.35	---
Cooperative (SPCCOOP)		0.25	0.43	---
Pesticide Agent (SPCAGENT)		0.42	0.50	-
Training (SPCTRAIN)		0.05	0.22	---
IPM Awareness (HEARD)	1= if farmer has heard of IPM before the survey; 0= otherwise;	0.28	0.45	+
IPM Training (ATTEND)	1= farmer attended an IPM training; 0= otherwise;	0.17	0.4	+
EXPERIENCES AND AWARENESS ABOUT IMPACTS OF PESTICIDE USE				
Use of Preventive Measures against Pesticide Exposure (PREVENT)	Scale from [1 to 5] representing number of precautionary measures employed	3.98	0.89	+
Health Impact (SICK)	1= farmer got sick after spraying pesticide; 0= otherwise;	0.26	0.44	+
Environmental Impacts (OBSENV)	1= farmer observed bird kills, fish kills, pesticide resurgence, and farm animal poisoning after pesticide application; 0= otherwise	0.35	0.48	+

[a] The mean values of the qualitative variables refer to the proportion of 176 onion producers taking on a particular qualitative attribute, and the means of the continuous variables simply refer to average values for the sample.
[b] Variable dropped from the model to avoid a singular matrix.

Source: Summary statistics are based on results of descriptive analysis of survey data; the expected signs are distilled from the adoption literature

The Dependent Variables

The dependent variable represents farmers' willingness to adopt each of the IPM CRSP technologies. This is a binary variable that takes on a value of one if the farmer indicated willingness to adopt the technology and a value of zero otherwise. Since the IPM CRSP technologies are still in their experimental phases, actual adoption rates are not available. Information on willingness to adopt the technologies under the IPM CRSP technology package was obtained to construct the five binary dependent variables: (1) TRIWKLY, (2) ONEHERB, (3) RHULL, (4) CASTOR, and (5) VIRUS. Willingness to adopt responses were elicited by describing each technology including their experimental results and asking each respondent the question: "*if technology x becomes available will you adopt or not?*" Definitions and summary statistics are provided in the following table.

TableIII.16. Willingness to Adopt Responses by Technology

VARIALE	**No. (%) of Farmers**		**DEFINITION**
	Willing-to adopt (=1)	**Not willing to adopt (=0)**	
TRIWKLY	159 (94)	11 (6)	Reduced insecticide (Brodan) applications from weekly (farmer's practice) to tri-weekly
ONEHERB	156 (93)	12 (7)	Reduced herbicide application from twice to once in a cropping season (50% reduction)
RHULL	76 (44)	96 (56)	Rice Hull Burning
CASTOR	88 (51)	85 (49)	Use of Castor as a Trap Plant
VIRUS	82 (48)	88 (52)	Use of Bacillus thuringiensis (Bt) and Nuclear Polyhedrosis Virus (NPV)

Step 4. Assessing Effects of IPM Adoption on Pesticide Use

Since IPM affects the use of pesticides, it therefore also affects the amount of external costs generated by pesticide application. The potential reduction in pesticide use under an IPM program is estimated by focusing on results of field experiments of the different IPM-CRSP technologies. The results give an indication of how much of a reduction in pesticide use is expected if the various technologies were adopted. A summary of the experimental treatments and results are presented in Table III.17 Results of experiments are reviewed in a succeeding section. Ultimately, the reductions in pesticide use per unit area will be estimated.

The IPM CRSP Research Activities/Technologies Selected for Evaluation

Research under the IPM CRSP in the Philippines is centered on the development of alternative pest control technologies specific to rice-vegetable cropping systems predominant in Nueva Ecija. Field experiments for different IPM CRSP technologies have already been undertaken both in controlled environments or laboratories and on rice-vegetable farms owned by local farmer-cooperators. The IPM CRSP activities encompass a wide range of pest control research that include among others: 1) studies on appropriate use of pesticides; 2) complementary weed control strategies, such as rice straw mulching with reduced herbicide application; 3) cultural controls like rice hull burning; 4) nematicide substitutes in the form of soil amendments; and 5) biological controls using viruses and natural enemies to control insect pests.

To evaluate the benefits of the IPM CRSP in the Philippines only a subset of all the technologies being developed under the program was selected. Selection of the specific technologies for evaluation was based not only on the existence of preliminary, nonetheless conclusive experimental results, but more importantly, on their potentially high impact in reducing pesticide usage among rice-onion farmers.

<u>Field evaluation of insecticide treatments against onion thrips</u>

Field monitoring of farmers' use of insecticides for the past two years consistently showed very high application levels with up to eleven treatments per season against onion thrips and Spodoptera. This experiment was therefore designed to determine the optimal frequency of application of the commonly used insecticides in the region, as well as to explore the most effective but least hazardous among these widely used insecticides. Two hypotheses were tested: 1) the frequency of insecticide applications on the target pests can be reduced while maintaining or improving yields of the target crops; and 2) carbamates provide better control than pyrethroids or organophosphates on the target pests. The experimental results indeed showed that onions (*tanduyong*) can be grown without the use of the insecticide- Brodan, a combination of Chlorpyrifos and BPMC, that controls onion thrips. The different treatments--weekly, biweekly, triweekly, and no Brodan (control) applications showed no significant differences in onion-thrips densities for the tanduyong variety. Despite the control treatment's (no Brodan) high mean number of thrips per plant, it still posted the highest mean yield (tons per hectare). Furthermore, the experiments indicated that high thrips population pressure that normally occurred after March was avoidable by transplanting the onions in December or early January. Finally, observations from experimental plots revealed that the common perception by onion farmers that thrips densities drastically increased after the February and March rains lacked any strong scientific basis, making it another misperception.

A noteworthy recommendation derived from this experiment states that if the thrips population is less than 10 thrips per plant and remains consistently low throughout the onion-growing season (January-March), insecticide treatments are unnecessary and therefore economically wasteful.

Complementary weed control strategies in rice-vegetable systems

Weeds can cause losses of up to 50% or more in yield if they are not controlled. A number of farmers have been known to spend almost one-third of their total operating costs for weeding and for herbicides. Only until alternative cultural or biological methods of weed control are developed will there be a significant reduction in herbicide use among farmers. Meanwhile, it is also important to fine-tune herbicide application rates and prevent injudicious use of toxic chemicals. Hence, studies on efficient herbicide field use rates and timing of application were conducted.

This experiment was specifically designed to determine the effects of herbicides on the growth of weeds infesting the rice-vegetable system. It was hypothesized that fine tuning the rates and timing of herbicide use would reduce herbicide use while maintaining or increasing vegetable yields; and herbicides combined with handweeding is more cost-effective in controlling weeds than herbicide use alone. The strategies under consideration for weed control were different combinations of cultural methods such as rice straw mulching and hand weeding, and a reduced herbicide application technique.

Results indicated that in mulched[15] onion fields, the combination of one herbicide application (of *glyphosate*) followed by 1 handweeding was just as good as the farmers' practice of 2 herbicide applications (*glyphosate* and *fluazifop*) followed by two handweedings. Hence, a fifty- percent (50%) reduction in chemical use (particularly, fluazifop) as well as savings in labor costs provide the same results as the farmers' usual practice.

While the onion fields mulched with rice straw did not show any apparent influence on thrips populations, rice straw mulching nonetheless provided effective weed control. Moreover, yields in mulched fields were more than three times higher than in unmulched fields. Since rice straw mulching was confirmed to suppress weed growth considerably, its greatest contribution can be felt in its ability to partially substitute for herbicide use in onions.

Potential for *Nuclear Polyhedrosis Virus* (NPV) and *Bacillus thuringiensis* (Bt) for *Spodoptera* control in Yellow Granex Onions

This research ativity was designed to: 1) evaluate commercially available Bacillus thuringiensis (Dipel, Thuricide, and Agree) and LEP-22 against Spodoptera litura (the common cutworm); 2) produce a strain of nuclear polyhedrosis under the CRSP to be used for field trials in combination with the best Bt in the market; and 3) evaluate the efficacy of the NPV from Los Banos, the NPV from AVRDC, and the CRSP's NPV. The premise is that Bt is an effective and economically viable control measure for S. litura in onions. A test was also made to assess if NPV is a more effective control for S. litura if combined with Bt than if Bt is used alone.

All the three NPVs were successfully mass-produced for field trials. These field trials revealed that Bt combined with NPV was more effective against *Spodoptera* larvae than NPV alone, Bt alone, or Karate insecticide application. Onion yields (yellow granex) in Bt + NPV-treated plots and Karate-treated plots were comparable, thereby proving that the Bt + NPV strategy is a good substitute for insecticide use (specifically Karate) since yields were not affected. The use of Bt + NPV and NPV alone were also reported as

[15] Rice straw mulching is a common cultural control practice among onion farmers in Nueva Ecija.

promising for *Spodoptera* management, hence more field trials are underway to validate this assertion.

Effects of rice hull burning on soil-borne diseases, weed survival and growth, and rice-root-knot nematode, *Meloidogyne graminicola* in a rice-onion cropping system

Rice hull burning (RHB) originally targeted specifically for weed control, might very well have a substantial contribution in reducing the incidence of diseases such as pink root and in reducing the growth in nematode populations. These possibilities were explored in experiments in farmers' fields.

This research assessed the effectiveness of rice hull burning in controlling soil borne diseases, in suppressing weed populations and reducing weed survival and regeneration, in affecting root-knot population levels, and their effects on onion yields. The expectations were that rice hull burning reduces soil borne diseases, weed populations, nematode infestations, and increased yields. The soil-borne diseases studied included damping-off, bulb-rot, and pink root.

The incidence of soil borne diseases (particularly Fusarium spp) on burnt (RHB) plots was indeed lower. It was concluded that rice hull burning was an effective strategy in controlling and decreasing nematode populations in the soil. In fact, RHB effectively killed nematodes up to a soil depth of 6 inches. It successfully reduced nematode root galls and densities both in the roots and in the soil. The results further indicated adequate season-long suppression of weed growth, particularly grasses and sedges by rice hull burning. Weed emergence in unburned fields was greater by 74%, but extremely slow in burned fields, indicating that burning effectively destroyed weed seeds and propagules. Finally, onion yields were almost three times higher in burned fields; hence, rice hull burning can be considered a yield-enhancing strategy.

The Effectiveness of trap plants and pheromone traps for *Spodoptera litura* and *Leucinodes orbonalis* management

The motivation for undertaking this research came from the difficulty in regulating *S. litura*, a polyphagous pest, therefore efforts were intensified to find alternative measures to control this pest. The use of trap plants was believed to be relatively easy to use and environmentally safe. Also, since sex pheromones are very species-specific, beneficial arthropods are not affected. These chemicals are used in very minute quantities, do not accumulate in the environment, and do not have toxic effects. The problem is that sex pheromone tend to be costly, making this strategy cost-effective only if they are used in small quantities.

The objectives of this research were to determine the benefits of using the castor plant as a trap plant, to evaluate pheromone traps as an indicator of the relative abundance of *S. litura* and *L. orbonalis*, and to assess pheromone mating disruption techniques also for *S. litura* and *L. orbonalis*. It was hypothesized that the castor plant can be effectively used to attract *S. litura* and help prevent further damage to the onions, that using mating disruption techniques is a cost-effective pest management strategy, and that pheromone traps can be a good indicator of pest abundance. The experiments were for the yellow granex (export quality) onion variety. There were no conclusive results for the effectiveness of pheromone mating disruption techniques. However, it was noted that the pheromone traps provided a good indication of the prevalence of pests like the armyworms.

On the other hand, initial results for the use of castor as trap plants in controlling *S. litura* larvae showed that onion fields surrounded with castor plants had lower cutworm larvae per plant. Castor plant catches, although erratic, went as high as 116 young cutworm larvae per leaf starting one month after transplanting, indicating its potential as trap plant for *Spodoptera*.

Table III.17. The IPM CRSP Experiments and Results

IPM CRSP TECHNOLOGY/ ACTIVITY	TARGET PEST/ DISEASE	ONION VARIETY	PESTICIDE	ACTIVE INGREDIENT	SITE	TREATMENTS	RESULTS		IMPACTS
							EFFICACY	PRODUCTIVITY	
Optimal Frequency of Insecticide Application	Onion Thrips	Tanduyong	Brodan	Chlorpyrifos + BPMC	Sto. Tomas	1. No Brodan 2. Weekly 3. Biweekly 4. Triweekly	No significant differences in onion thrips density among treatments	T1 had the highest mean yield among the treatments	100 % reduction in insecticide use is a viable option if thrips population is < 10 per plant
Use of Alternative Weed Control Strategies: • Reduced Herbicide Treatments • Rice Straw Mulching	Weeds: • Grass • Broadleaf • Sedge	Tanduyong	Roundup Onecide Goal	Glyphosate (G) Fluazifop P-Butyl (F) Oxyfluorfen (O)	Sto. Tomas	1. G + F + 2HW 2. G(A) + 1HW 3. G(B) + 1HW 4. HW 2X 5. Unweeded + Rice Straw Mulch	T1, T2, T3, T4, T5 had same weed control efficacy against grass and broadleaf; T1, T3, T4 had same control efficacy for sedge	No significant differences in onion yields among treatments Plots with rice straw mulch had higher yields compared to those w/o	50 % reduction in herbicide use is a viable option Rice Straw Mulching reduced/suppressed weed growth
					Bongabon	1. O + F + 2HW 2. F + 1HW 3. G(B) + 1HW 4. G(A) + 1HW 5. Unweeded 6. Handweeded No rice straw mulch	T2 is just as effective as T1 against sedge, grass, and broadleaf	No significant differences in yield among treatments 1,2,3, and 6 Unweeded plots had the lowest yields	
Potential for Nuclear Polyhedrosis Virus (NPV) and Bacillus Thuringiensis (Bt) as Effective Microbial Agents	Spodoptera (cutworms)	Yellow Granex	Karate	Lambda-cylhalothrin	Bongabon	1. NPV 2. Bt 3. NPV + Bt 4. Karate 5. No Insecticide	Larval counts in all microbial treatments (T1,T2,T3) were lower than Katate treated plots (T4)	No significant differences in yields among T1,T2,T3,and T4 T3 had the highest yield	Use of NPV + Bt and NPV alone are viable alternatives to insecticide control without any loss in efficacy and onion productivity
					Palestina	(same as above)	Inconclusive results (cutworm density was too low to demonstrate the effects of the different treatments or show the differences in efficacy)	No significant differences in yields among the treatments T3 had the highest yield	

continued, **IMPACTS OF THE IPM PROGRAM ON PESTICIDE REDUCTION**

IPM CRSP TECHNOLOGY/ ACTIVITY	TARGET PEST/ DISEASE	ONION VARIETY	PESTICIDE	ACTIVE INGREDIENT	SITE	TREATMENTS	RESULTS		IMPACTS
							EFFICACY	PRODUCTIVITY	
Cultural Control of Onion Weeds and Diseases Through Rice Hull Burning (RHB)	Pink Root Disease Root-Knot Nematode Weeds (*Cyperus rotundus*)	Yellow Granex	Fungicides • Dithane • Benlate • Etc. Herbicides • Goal • Roundup • Onecide • Etc.	• Benomyl • Mancozeb • Oxyfluorfen • Glyphosate • Fluazifop P-Butyl	Palestina	1. Burned (RHB) 2. Unburned (no RHB)	Fungal populations were much lower in T1 Heat generated by RHB effectively reduced nematode populations RHB reduced weed density by 88% and fresh weight by 79%	T1 produced twice as much yield as T2	Rice hull burning effectively suppressed soil-borne pathogens, weed growth and survival, and nematode populations resulting in higher yields and improved quality of onion bulbs (bigger and heavier bulbs)
					Bongabon	(same as above)	Efficacy results followed a similar trend as results in Palestina	Yields were lower in T1 (this was attributed to armyworm infestation)	
Use of Trap Plants and Pheromone Traps to Control Common Onion Pests	Worms: *Spodoptera litura* *Leucinodes orbonalis* *Helicoverpa armigera*	Yellow Granex	Insecticides ▪ Cymbush ▪ Decis R ▪ Karate ▪ Etc.	▪ Cypermethrin ▪ Deltamethrin ▪ Lamdacyl-halothrin	San Jose Bongabon	1. W/Castor 2. W/o Castor	Initial results showed that onion fields surrounded with castor had lower cutworm larvae / plant	Not applicable	Castor used as a trap plant is a viable alternative to insecticide application
					Sto.Domingo Bongabon	1. W/Pheromones 2. W/oPheromones	T1 effectively attracted *Spodoptera* and *Helicoverpa* T1 was effective in quantifying *S. exigua* Overnight catches in T1 reached up to 81 adults per trap	Not applicable	Pheromones can be used as an effective pest monitoring strategy

Step 5. Estimating Society's Willingness-to-Pay to Reduce Pesticide Risks

Many researchers seem to agree that carefully constructed surveys can give meaningful values for environmental goods/amenities (Mitchell and Carson, 1989). This belief extends to surveys conducted in third world countries among poor respondents with limited educational attainment (Whittington, 1996). A contingent valuation survey was conducted to estimate prices (willingness to pay estimates) for the various environmental/health categories in order to calculate the savings attributable to the IPM program (Savings = WTP * amount of pesticide reduction due to IPM * population). Strategies were used to avoid biases that are inherent in a hypothetical survey and tests were used to identify whether these biases exist.

Contingent Valuation and Willingness to Pay

To be able to estimate savings in social costs attributable to an IPM program, an estimate of society's willingness to avoid the risks associated with pesticide use is imperative. There are no market values for this willingness to pay, but a hypothetical market can be constructed using the concept of contingent valuation.

For decades, economists have grappled with the challenge of valuing public goods. The contingent valuation method (CVM) is one of the few ways that have been developed to accomplish this demanding and important task. The CVM uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified improvements in them. The method is thus aimed at eliciting their willingness to pay (WTP) or willingness to accept (WTA) compensation in monetary units. It circumvents the absence of markets for public goods by presenting consumers with hypothetical markets in which they have the opportunity to buy the good in question.

Specifically, CV devices involve asking individuals, in survey or experimental settings, to reveal their personal valuations of increments (decrements) in unpriced goods by using contingent markets. These markets define the good or amenity of interest, the status quo, level of provision, and the offered increment of decrement therein, the institutional structure under which the good is to be provided, the method of payment, and (implicitly or explicitly) the decision rule which determines whether to implement the offered program. Contingent markets are highly structured to confront respondents with a well-defined situation and to elicit a circumstantial choice contingent upon the occurrence of the posited situation (Cummings et al., 1986).

The CV method however has been heavily criticized based on its reliability and validity. A major concern with the use of the CV method has been the potential for survey respondents to give biased answers. There are several general types of potential biases:

1. *Strategic Bias*. This bias may arise whenever a respondent provides a biased answer in order to influence a particular outcome, that is, a respondent may behave strategically and not reveal his/her true preferences (i.e. by acting as a "free-rider").
2. *Information Bias*. This may arise whenever respondents are forced to value attributes with which they have little or no experience.
3. *Starting Point Bias*. This may arise in survey instruments in which a respondent is asked to check his/her answers from a predefined range of possibilities (referred to as a bidding game). The consequence of this bias is that the mean final bid may differ with different starting points in bidding games.
4. *Vehicle Bias*. Different forms of payment elicit different bias and the vehicle should therefore correspond reasonably well to how people actually would pay for the environmental improvement.
5. *Hypothetical Bias*. This occurs when the respondent is being confronted by a contrived, rather than actual, set of choices. Since the respondent will not have to actually pay the estimated value, the respondents may treat the survey casually, providing ill-considered answers.

A carefully constructed survey can minimize these potential biases and therefore can give meaningful information about consumer preferences for all non-market/environmental goods (Cummings et al., 1986; Mitchell and Carson, 1989). The principal challenge of this CV survey is to make the scenario sufficiently understandable, plausible, and meaningful to respondents so that they can and will give valid and reliable values despite their lack of experience with one or more of the scenario's dimensions.

There are several steps to be followed in this CV study, including use of techniques to avoid possible biases. The first step involves designing a survey questionnaire, which generally consists of three parts:

1. A detailed description of the good(s) being valued and the hypothetical circumstances under which it is made available to the respondent.
2. Questions which elicit respondents' WTP for the good(s) being valued.
3. Questions about respondents' characteristics (i.e., age, income, etc.), their preferences relevant to the good(s) being valued, and their use of the good(s).

While developing the questionnaire, the research procedure, elicitation method and payment vehicle should be taken into consideration. The research procedures may include survey by mail, telephone, personal interview, focus group or laboratory. The survey in this study was conducted via personal interviews, to ensure that respondents understood the questions and the researcher could easily evaluate possible outliers. The sample (n=176) was selected randomly from among the 4,572 San Jose farmers and from the 210 members of a successful farmers' cooperative in Bongabon.

The elicitation method is the technique used to evoke a valuation response. There are four approaches:

1. *Direct Question Method* - simply asks the respondent the question "What is the most you are willing to pay for this environmental good?"
2. *Bidding Game* - starts with some WTP amount and in response to "yes" replies, increase the amount progressively until the respondents say "no". Conversely, one should decrease the amount until a "yes" response is obtained if the respondent says "no" to the initial amount.
3. *Payment Card* - gives respondent a card with an array of dollar numbers starting with zero. The respondent is asked what number on that card (or a number in between) represents his/her maximum willingness to pay for the good in question.
4. *Binary Discrete Choice* - obtains a single discrete response to a take-it-or-leave-it type of question.

Because the respondents of this survey involve farmers who may or may not have a complete understanding of the complex risks posed by their pesticide applications, the survey instrument should be descriptive and understandable by the Filipino farmers. In addition to clear wording and possible graphic depiction of risks, the survey instrument should also be meaningful and close to farmers' experiences. Van Ravenswaay and Hoehn (1991) developed a simulation approach that makes this possible, whereby the problem of hypothetical bias is avoided (Owens et al., 1997). The approach involves simulating a market for a private good that is very similar to another good that is already very familiar to the respondents, but with some variations in the attributes of the good. The hypothetical bias is said to be reduced because respondents are more likely to understand the market scenario and be able to predict their likely choices. Respondents are asked a number of questions about their actual purchases of the familiar good (such as a certain popular type of pesticide) at different prices and, from this data, demand for the familiar good is estimated.

The farmers in the Philippines were asked about their use of these pesticides and to evaluate formulations of these pesticides with fewer health and environmental effects. Prices and related market conditions were specified to encourage respondents to assess similar market situations. In particular, different formulations that are described as safe for the different impact categories were valued by the respondents.

To estimate the willingness to pay for the environmentally-friendly good, data on factors affecting the demand for pesticides were gathered. These included price of the pesticide, prices of substitutes, production practices, as well as farmer and farm characteristics.

This WTP estimate refers directly to the value that onion producers place on improvements in environmental quality or conversely, risk avoidance. This study determines the willingness of the farmers to pay for reduction of these risks and these WTP estimates for various constructed environmentally safe pesticide formulations indirectly provide them. Based on the farmers' demand for safe pesticides, their demand for reductions in the risks of pesticides for different categories are determined.

Step 6. Estimating the Benefits of the IPM-CRSP in the Philippines

The benefits of the IPM CRSP in the Philippines is quantified by combining the estimated reductions in risks as a result of IPM adoption with elicited willingness to pay of onion producers for risk avoidance. This estimate represents the monetary savings attributable to the program based on the five selected IPM CRSP technologies and their impacts on reducing risks to five environmental categories (or non target receptor groups). The estimation procedure brings together results from prior steps as follows:

(1) Step 1 provides the relevant environmental categories affected by pesticide use in onions. These group are the basis for the analysis of risks and willingness to pay;

(2) Step 2 provides the impact scores or risk scores of insecticides, herbicides, and fungicides used in onions;

(3) Step 3 provides the adoption rates of IPM CRSP technologies among the onion producers;

(4) Step 4 provides the amount of reduction in insecticide, herbicide, and fungicide uses (based on experimental results) as a result of IPM CRSP adoption (using adoption rates from step 3);

(5) The reduction in risks is derived by calculating the change in the ecological rating scores from current pesticide use patterns to the predicted changes in pesticide use patterns induced by IPM adoption;

(6) Step 5 provides mean willingness to pay values obtained using the contingent valuation method;

Finally, the percentage change in risks (risks avoided) is combined with WTP for risk avoidance to come up with the health and environmental benefits of the IPM CRSP.

The results of the step-by-step procedure are reported in Chapter Five. The next chapter describes the survey conducted by personal interviews with onion producers in Nueva Ecija.

CHAPTER FOUR
THE SURVEY

This section describes the survey process undertaken in this research. It starts off by presenting the difficulties faced by the enumerators in gathering accurate and reliable information, and the challenges faced by the principal investigator in designing the survey instrument. A description of the three groups of respondents that were targeted for this survey is provided, with the rationale for choosing these groups. Finally, the survey variables by area of classification are discussed.

The Challenges: Administration and Design of Survey

The survey was completed via personal interviews using carefully constructed survey questionnaires (Appendix A). Interviews were conducted over a period of three and a half months, from November of 1997 to February of 1998. This period which coincided with the beginning of the dry season, also considered the vegetable season in the region[16]. The first two months of the vegetable season are the most intensive in terms of labor requirements because of land preparation and planting. Hence, from November through December, interview times were limited to lunch hour and late afternoon sessions, usually after farmers returned to their homes from a day's work in the fields. Ideally, information must be gathered right after the cropping season to make it easier for respondents to remember details of their operations and avoid any recall problems. For this survey, farmers were asked to recall information about their vegetable growing practices from a year ago (the 1996-1997 dry season). Naturally, some farmers had a hard time thinking back and may have given less accurate information especially about their pesticide usage.

The instrument was pre-tested on three separate occasions among farmers in Sto.Tomas, Nueva Ecija. As a result of the pre-testing, the following modifications were made: 1) on questions that used Likert scales to ask respondents to rate the severity of their pest problems and the degree of importance of the various risk categories, the questions had to be reworded using descriptive terms like negligible, moderate, and extreme (or not important, somewhat important, and very important), and reducing the 5-

[16]Most farmers in the region follow a rice-vegetable cropping system and vegetables are predominantly grown during the dry season.

point numerical scale to a 3-point scale with more descriptive terminology; 2) on the contingent valuation questions, the intention was to elicit respondents' willingness-to-pay for avoidance of low, medium, and high risks associated with 5 impact categories—in effect, asked respondents to offer 15 different price valuations that made the CV survey complicated and difficult to administer. The CV questions were therefore reduced to 5 willingness-to-pay questions corresponding to the 5 risk categories; 3) on the question that involved ranking the different categories in order of importance, enumerators used a separate form wherein the five risk categories were listed. In addition to this list of categories, specific examples known to be familiar to the respondents were used to describe each category more clearly. For example, in ranking the importance of avoiding human health risks, specific health symptoms like dizziness, nausea, skin irritations, and stomach problems were mentioned. The question used was-'*what rank would you assign to the importance of avoiding these specific health problems that are associated with pesticide exposure*'. For the farm animal category, the cow and the carabao were used as examples; the "tilapia" was used for the fish and other aquatic species category, and for beneficial insects, examples used were the spiders and dragonflies[17]. These modifications made ranking decisions easier compared to verbally enumerating the 5 general categories and asking the farmers to assign numerical rankings. In addition, associating specific examples to each impact category made the questions easier to comprehend.

The objective in mind when the survey instrument was designed was to make questions simple, direct and nonrepetitive, using as many examples and visual aids as possible. The reason for aiming for clarity and simplicity was that the survey involved farmers who may have had very limited educational backgrounds and may not have had any previous survey or personal interview experience. All the modifications mentioned above were therefore necessary to achieve this objective.

A brief introduction about the researchers and institutions involved in the study, and a general description of the topic and objectives of the survey were presented at the beginning of each interview. In each of the study sites, the standard operating procedure

[17] The dragonfly and the spider were reported to be the most familiar natural enemies known to farmers in San Jose, Nueva Ecija (Lazaro et al, 1995)

prior to conducting interviews that proved very helpful, was to make courtesy calls to the elected village heads, referred to locally as barangay captains (or Kapitan)[18]. This was particularly useful in getting directions to selected respondents' homes. In some cases, subordinates of the barangay captain (the barangay "tanods") were sent to gather the respondents in the barangay hall where interviews were conducted[19], and in other cases the "tanods" went with the researchers from house to house. Not only was this system helpful in finding the respondents, but it also helped in obtaining the farmers' cooperation to participate in the survey. Some respondents were reluctant to share information and their time partly because of the inconvenience involved and partly because of unfavorable experiences in the past. Other farmers expected compensation by way of free seeds or free fertilizers (especially when PhilRice and IRRI were mentioned as collaborators) and were unwilling to participate if none was offered.

The most crucial and difficult information that had to be acquired was on farmers' pesticide usage. Confusion about the chemicals applied to rice pests and onion pests was common. Enumerators had to be specific in asking about the kinds and amounts of pesticides used on onions. Some respondents could only recall using a small, medium, or large bottle of a pesticide which usually meant a 250-ml, 500-ml, or a 1-liter bottle of pesticide. The strategy adopted by the enumerators in getting more accurate information was to ask respondents to show them samples of pesticide bottles or labels they have used during the onion season.

The Respondents

A total of 176 onion farmers were interviewed. Of this number, 110 respondents were drawn from the San Jose sites (the San Jose Group), thirty (30) farmers were drawn from Bongabon (the NOGROCOMA group), 36 were from Munoz. Figure IV.1 shows the breakdown of respondents in each group.

The list of onion farmers was obtained from the office of the Municipal Agriculturist in San Jose City. A random sample of farmers in each of the identified sites

[18] Barangay Captains of Abar 1st, Palestina, Sto.Tomas, and Munoz were all approached prior to conducting interviews in these sites. In Bongabon, a NOGROCOMA official was the contact person.

[19] The first 15 respondents in Palestina were gathered and interviewed in the barangay hall. Although this system made it logistically easier for the enumerators, it also made it difficult to record pesticide usage, because in order to get specific information about the toxicity or amount of active ingredients in the chemicals the bottles or labels had to be seen.

was taken from this master list. Three groups of respondents were considered—the first group of respondents is a random sample of farmers from three barangays in San Jose, Nueva Ecija-- Sto.Tomas, Palestina, and Abar 1st. These three sites together with three other barangays were pre-selected sites for the IPM-CRSP activities. These barangays were chosen based on the following criteria: 1) proximity to the Philippine Rice Research Institute (PhilRice); 2) similarity in farmers' practices; 3) farmers' willingness to cooperate; 4) presence of farmer organizations or cooperatives; 5) vegetable growing before and after rice; 6) heavy insecticide use; and 7) no IPM training among farmers. Currently, there are several on-going field experiments on alternative pest management strategies, such as the use of biological controls, weed experiments, and cultural methods that are being conducted by IPM-CRSP researchers in these areas.

The second group is a random sample of farmers that are members of the National Onion Growers Cooperative, Marketing Association, Inc. (NOGROCOMA) in Bongabon, Nueva Ecija. This group of respondents—the Bongabon Group can be characterized as uniquely comprised of a different breed of farmers compared to the more independent farmers in San Jose. The NOGROCOMA farmers are an organized group with proactive members. Members of the group have had extensive training on alternative ways of farming, including pest management techniques and are very open to adoption of new technologies. The group's exposure to novel and more safe ways of farming is made possible by their aggressive President and General Manager- Ms. Dulce Ilagan Gozon. She continually seeks advice from agricultural scientists and facilitates technology transfer through interactive training and symposia. This group almost has guaranteed credit support and marketing tie-ups through their association with Ms. Gozon, also an influential onion-wholesaler.

Some IPM-CRSP experiments have also been laid-out in member-farmers' plots and therefore the impacts of the program can likewise be estimated using this sample of farmers. Moreover, the influence or effect of membership in an organized cooperative in terms of IPM-technology transfer and adoption can be measured, providing insights into effective ways of intervention.

The third group of respondents represents a sample of farmers in the municipality of Munoz, Nueva Ecija. Farmers in this area have been exposed to integrated pest management techniques by way of IPM-training on rice, conducted by the Department of Agriculture. This sample of respondents is composed of a mix of farmers with and without rice-IPM training.

Evaluating the differences in personal characteristics, pest management practices, knowledge and perceptions about the effects of pesticides, and other socio-economic and environmental factors across the three different groups is useful in determining specific conditions or variables that may increase the probability of adoption and degree of integration of IPM technologies.

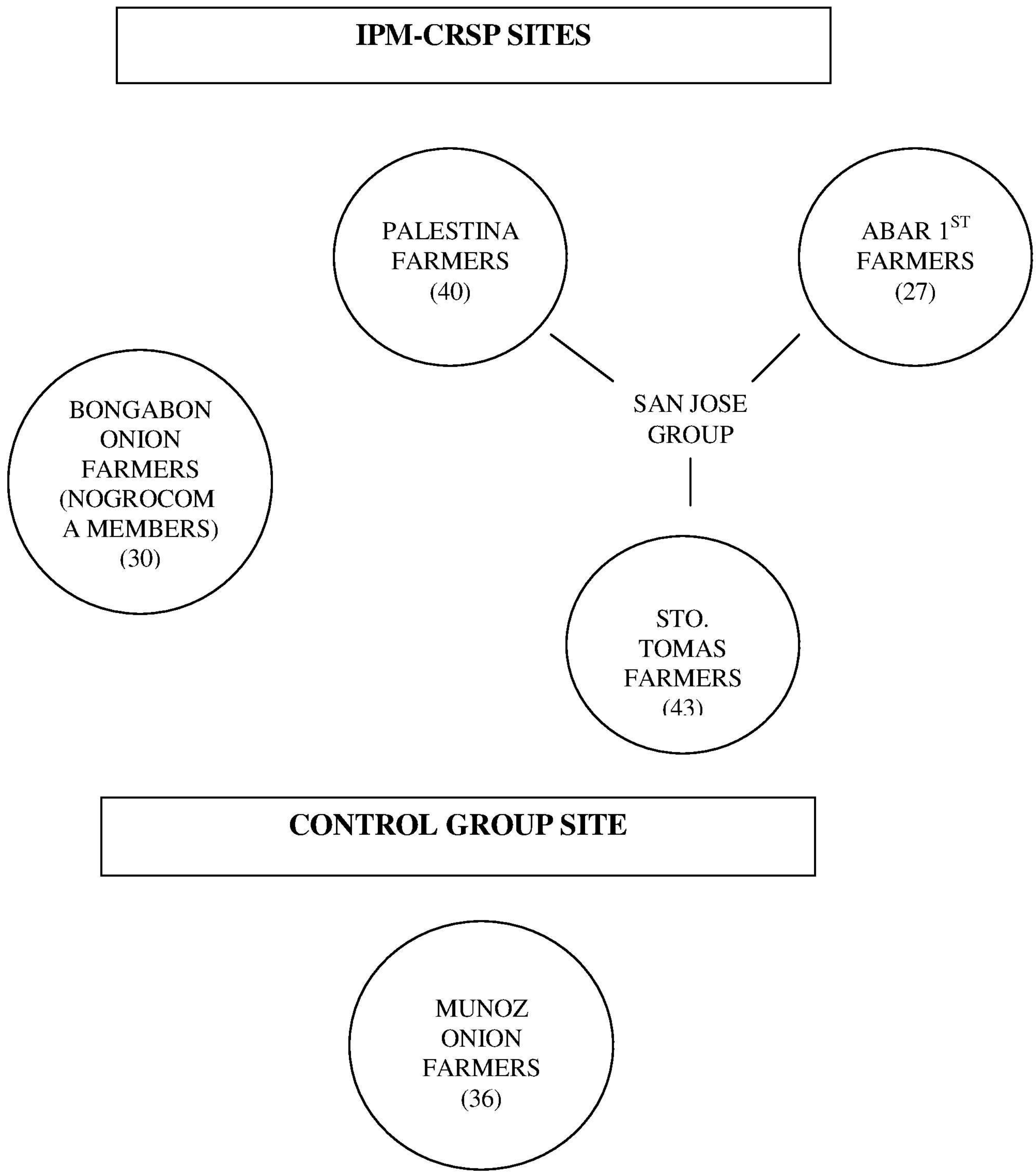

Figure IV.1. Breakdown of Respondents by Site

The Variables

The survey questionnaire was designed to secure information about onion farmers' farm operations/managerial inputs, personal characteristics, pest management practices, knowledge about IPM and adoption of IPM practices, and their perceptions about the health and environmental impacts of pesticides. In addition, questions about the respondents' willingness-to-pay for avoidance of risks to human health, birds, farm animals, beneficial insects, fish and other aquatic species were derived using the contingent valuation method. Table IV.1 shows the different variables or information gathered in the survey by area of classification.

Table IV.1. List of Survey Variables by Category

CATEGORY	VARIABLE
FARM CHARACTERISTICS	Farm Size
	Crops Planted
	Yields and Total Returns
	Soil Type
	Source of Water
FARMER CHARACTERISTICS	Farming Experience
	Age
	Educational Attainment
	Time Spent On-Farm/Off-Farm
	Net Income from Farming
	Tenure Status
PEST MANAGEMENT PRACTICES	Severity of Pest Problems
	Most Important Onion Pests
	Pest Control Methods
	Source of Pest Control Advice
	Pesticide Usage (dosage; frequency)
	Pesticide Expenses
	Factors Considered in Choosing Pesticides
KNOWLEDGE OF IPM AND ADOPTION OF IPM PRACTICES	Awareness of IPM Concepts
	Source of IPM Knowledge
	Description of IPM Techniques Learned
	Percentage Reduction of Pesticide Use
	Willingness-to-Adopt IPM-CRSP Technologies
PERCEPTIONS ABOUT THE HEALTH AND ENVIRONMENTAL IMPACTS OF PESTICIDES	Experience with Pesticide Impacts
	Degree of Importance of Pesticide Impacts
	Importance Ranking of Impact Categories
WILLINGNESS-TO-PAY AND RELATED INFORMATION	Protective Measures Against Pesticide Exposure
	Wage Differentials
	Price Premium on Risk Avoidance

CHAPTER FIVE

RESULTS AND DISCUSSION

A synthesis of results from the estimation and evaluation procedures described in the Methodology Chapter is presented in this chapter. It begins with a discussion of the results from the descriptive analysis of the survey data, and then proceeds with a discussion of the results from the step-by-step evaluation of the IPM CRSP in Nueva Ecija, Philippines.

Survey Results

This section describes the farm operations, pest management practices, knowledge of integrated pest management, perceptions about the impacts of pesticides, and personal characteristics of onion farmers in Nueva Ecija. One hundred seventy-six usable observations on 60 different variables were obtained from three major groups of respondents: the San Jose group (comprising of onion farmers from three villages, namely: Abar 1st, Palestina, and Sto. Tomas), the Bongabon group, and the Munoz group.

Farm Operations

The onion (*Allium cepa*) is a very profitable dry season crop in Nueva Ecija. Most of the onions in the region are grown in rotation with rice, usually being transplanted after rice sometime around November and harvested before the rains start in May. Land preparation and sowing start 45 days before planting, with harvesting occurring between 100 and 125 days after planting. Onions grow best in friable and fertile soils (PCARRD, 1981). The crop is most suitable to be grown in loamy soils like that of Abar 1st, Sto. Tomas, and Munoz, or the sandy loam soils of Bongabon, but not in heavy soils such as clay or clay loam, which is predominant in Palestina.

The yellow granex, red globe, red creole, and the shallot were the most common onion varieties[20] grown in the area. The shallot variety was most widely grown among the San Jose and Munoz farmers. The t*anduyong, batanes*, and *lasona* were the most popular shallot cultivars in San Jose and Munoz[21]. In one village in San Jose--A bar 1st- the tanduyong variety accounted for as much as 93 % of the dry season crops grown.

[20] Some of the more common brands of onion seeds planted in the region include: Kaneko, Key Stone, Takii, Rio Colorado, Asgrow 429, and Asgrow 33.

These native onion cultivars were grown more for domestic or regional consumption. In contrast, the onion varieties that the Bongabon group produced – mostly yellow granex and red creole - were almost exclusively grown for distribution outside of the region.[22] Food companies in Manila and Japan served as the biggest markets for these higher-grade onions. These onion varieties commanded higher prices in the market because of the size and the quality of the bulbs.

Besides producing higher-priced onions, the size of the onion operations in Bongabon were substantially larger compared to the other sites (Figure V.1). The average onion farm in Bongabon was five times bigger than the average farm size in San Jose and Munoz.

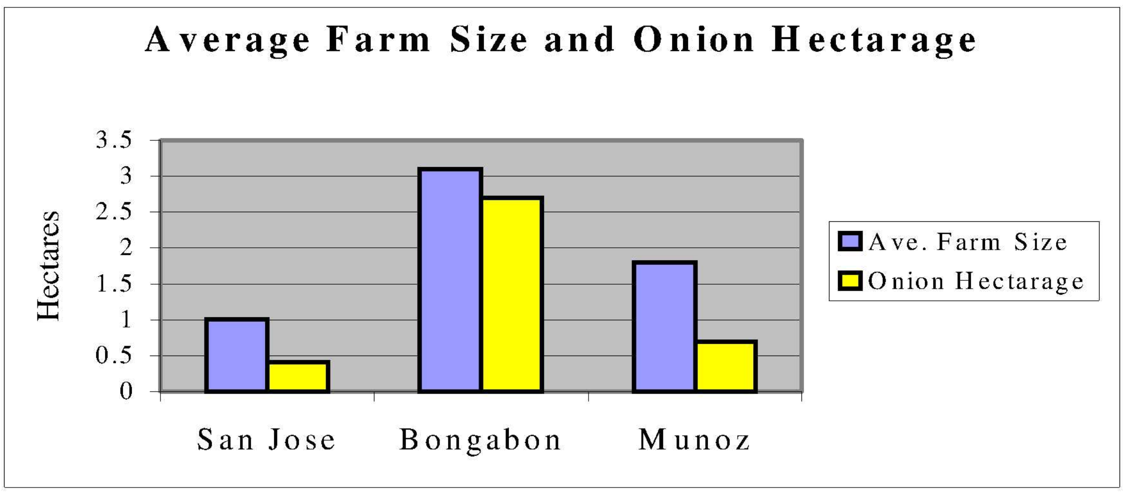

Figure V.1. Average Farm Size and Onion Hectarage in San Jose, Bongabon, and Munoz, 1997 Producer Survey

Onion production in Bongabon was considerably higher – based on the reported average yield of 40,000 kilograms per farm or 13,000 kilograms per hectare, relative to the 4,000 kilograms produced per farm in Munoz and San Jose (Figure V.2).

[21] *Cultivar* - another term used for (onion) *variety,* that which is commonly grown for commercial purposes. The cultivars, evolving from a long period of cultivation, can transform into many distinct forms adapted to specific environments and practices.
[22] Marketing and distribution of onions produced by the Bongabon group was handled by the NOGROCOMA marketing cooperative.

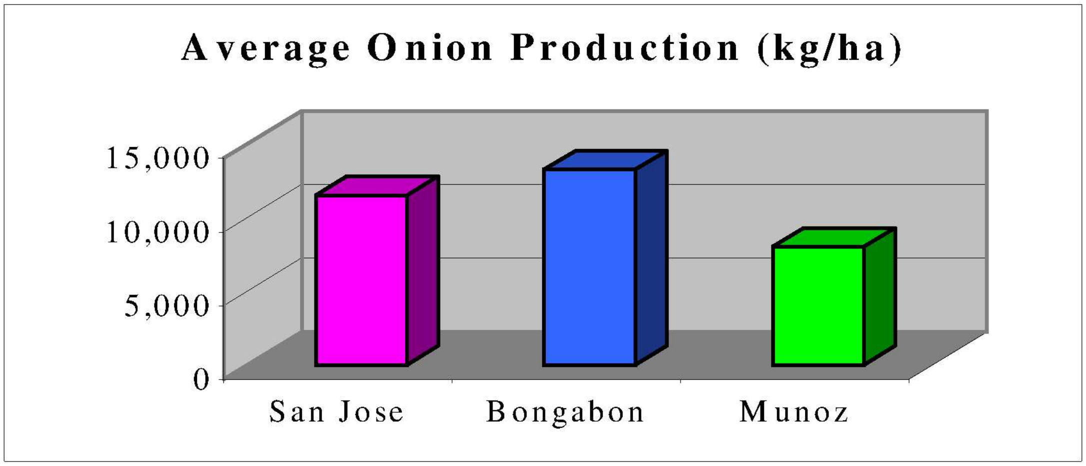

Figure V.2. Average Onion Production in San Jose, Bongabon, and Munoz; 1996-1997 Onion Season.

As expected, the Bongabon farmers posted the highest mean values for all the economic indicators. This group recorded the highest income from rice and onion, as well as from off-farm sources. More than half of their income was generated from onion growing. Profits from onion on the average were almost 46,000 pesos more than the average income from onion that farmers in San Jose and Munoz earned. San Jose and Munoz farmers generated more income from their rice production during the wet season.

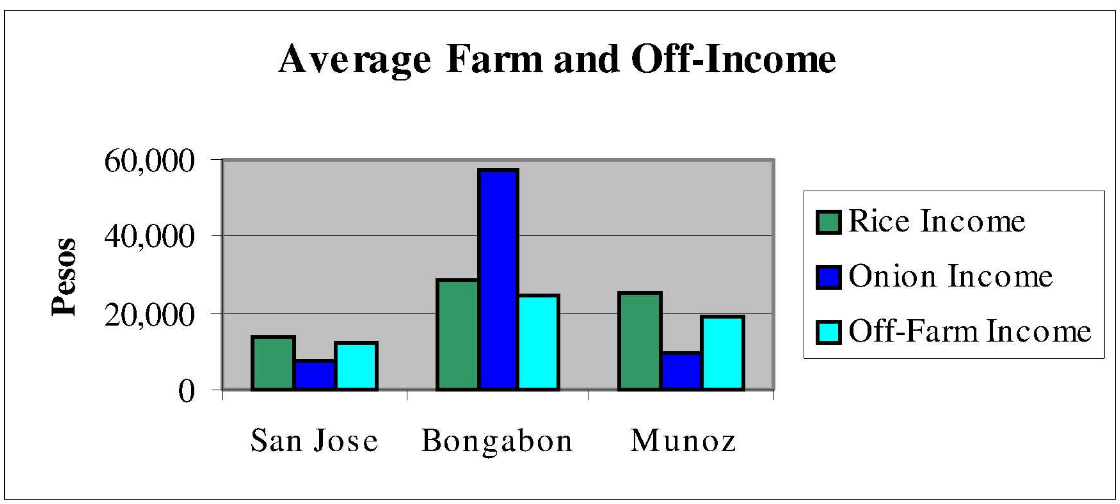

Figure V.3. Average Income Generated from Rice, Onion, and Off-Farm Sources in San Jose, Bongabon, and Munoz, 1996-1997 Cropping Season

In addition, farm wages for pesticide application, harvesting, and manual weeding were also higher by as much as 30 pesos in Bongabon compared to farm wages paid in San Jose and Munoz (Figure V.4).

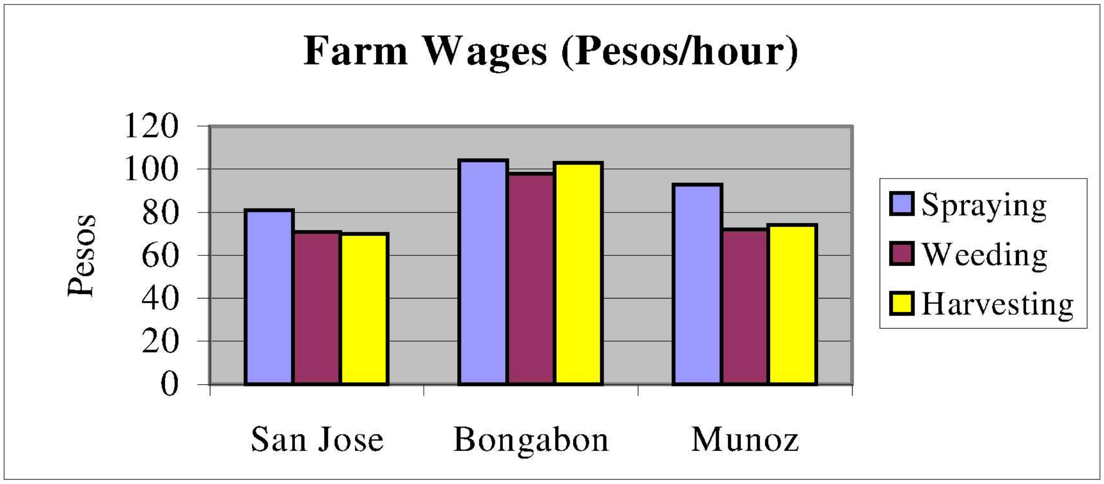

Figure V.4. Per Hour Farm Wages for Spraying, Handweeding, and Harvesting in San Jose, Bongabon, and Munoz, 1996-1997 Cropping Season

<u>Pest Management</u>

The control of onion pests and diseases such as weeds, insects, nematodes, and fungi is of vital concern among onion growers. Farmers devote a considerable amount of resources – time, money, and effort, to prevent crop damage and minimize profit losses from pest infestation.[23]

Onion Pests and Diseases

Control efforts in the region are mainly targeted towards onion thrips, cutworms, armyworms, and nematodes. There are also a number of viral and bacterial diseases that can seriously damage the onions such as damping-off and the pink root disease among others.

When farmers were asked about their most problematic pests, harmful insects and worms immediately came to mind. Yet, in addition to insect pests, onion plants are also very susceptible to weed competition, such that proper weed control throughout the growing season is a necessity. Unfortunately, this control is mainly accomplished through herbicide treatment, which is a cheaper alternative to manual weeding.

The onion thrips (*Thrips tabaci*) was cited in the survey as one of the most problematic insect pests in the region. Although farmers consider thrips as a problematic

[23] Previous studies have pointed out that there is a tendency among (Filipino) farmers to overestimate crop losses from pest damage that leads them to engage in unnecessary pest control activities. This risk aversion is partly motivated by the lack of any form of crop insurance that can buffer the economic repercussions of crop damage.

pest, perhaps due to their familiarity with the pest and with the associated symptoms of infestation, scientists at PhilRice identified nematodes as the more pressing pest problem because of their adverse effects on onion yields.

The presence and density of thrips in the crop can be monitored by examining sample plants, particularly by checking the necks closely and the leaves for pronounced dashes that streak together in whitish blots. Thrips can be controlled by washing-off the leaves using sprinkler irrigation, or by heavy rains. Simply maintaining large, turgid, and well-watered onion plants is an effective strategy against thrips attack, yet based on the survey, water treatment as a pest control method was used by only six percent of the respondents; despite the fact that thrips were considered by some of the farmers as one of the most prolific onion pests in the region.

Worms were another widely known onion pest among the farmer respondents. Some of the farmers were able to specifically recognize the armyworms and cutworms. Others were only able to describe the worms found in the fields – green, brown, black, white, tiny, spotted, and large, were the most common descriptors mentioned. Cutworms are considered the sneakiest onion pests, as they usually hide under rocks, trash or in the soil during daylight, and come out at night to attack the crops. There are various kinds of cutworms - mostly soft-bodied, smooth, plumb, cylindrical in shape – that grow up to one and a half-inches long. Their colors vary from greasy grey to brown, some marked with lighter or darker spots or stripes, others are dark brown or almost black. Cutworms are damaging to almost any kind of tender plant. The wireworms - hard, shiny, six-legged, yellow or brown wirelike worms, are another kind of pests that infest the soil and root systems of the onion. Injury to crops is done by destroying the seeds, cutting off small underground stems, and tunnelling through roots, bulbs, and tubers.

Among the onion diseases, damping-off was the most commonly cited. This disease can wipe out a crop of onion seedlings overnight (Coonse, 1995). Fungi in the soil cause the initial infection but the disease is spread more rapidly when weather conditions are cool, damp, and overcast.

Pest Control Practices

Chemical control was the primary strategy for preventing and destroying onion pests in all of the surveyed areas. Insecticides, herbicides, and fungicides were either incorporated in the soil or sprayed on the onion crops at various stages throughout the season. A recommended schedule for insecticide spraying is 15, 43, 57, and 73 days after planting; that is, at most four times per cropping season. Frequency of insecticide application in the study sites ranged from once to as many as 36 times in one cropping season. The average frequency of application[24] per site was 11 times in Bongabon, 4 times in Munoz, and 5 times in San Jose.

Insecticide use accounted for almost 50% of total chemical usage in all of the three sites (56% in San Jose, 46% in Munoz, and 52% in Bongabon). Likewise, herbicide use was over 40% of total chemicals applied in the area.

The most widely used insecticides in the region were Brodan (Chlorpyrifos) and Cymbush (Cypermethrin). For herbicides, the most popular brands were Onecide (Fluazifop-P-Butyl), Roundup (Glyphosate), and Goal (Oxyfluorfen). Dithane (Mancozeb) was the most commonly used fungicide. The pesticides used in the area were mostly liquid formulations, therefore were applied using backpack sprayers.

The amount of active ingredient applied per hectare in each of the sites is reported in Figure 5. As shown the Bongabon farmers on the average had the highest pesticide application rates among the groups of respondents in the area.

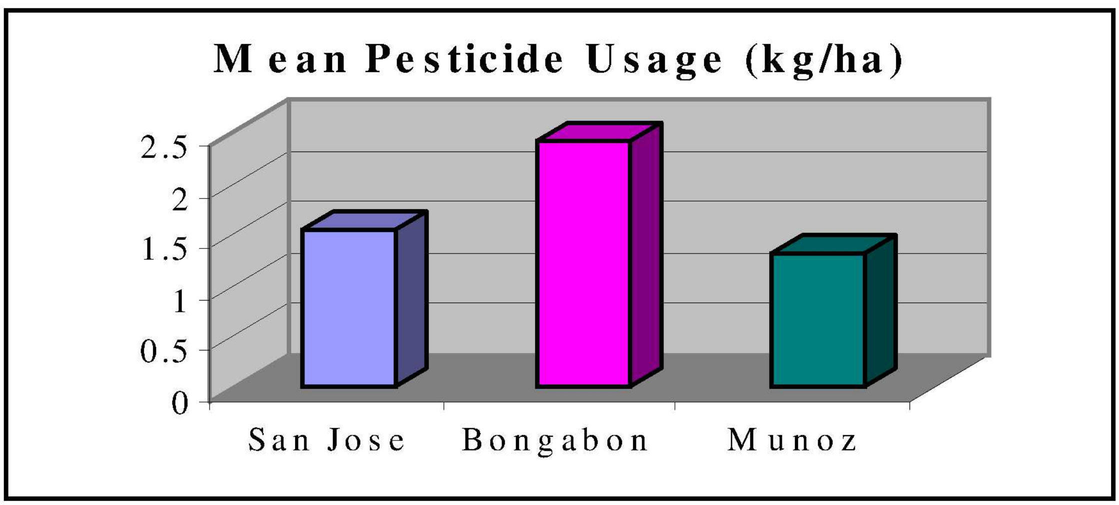

Figure V.5. Average Amount of Pesticide Active Ingredients Applied by Farmers in San Jose, Bongabon, and Munoz (kgs/ha), 1996-1997 Onion Season

[24] The average frequency of application was computed by taking the mean frequency of application across all the different brand names or trade names of insecticides.

Expenses on pesticides accounted for fifteen percent of the respondents' total operating expenses. The average cost of pesticides for the 1996-1997 onion season was about 3,000 pesos. By virtue of the size of their onion operations, the Bongabon group naturally applied more pesticides and spent more on chemicals. However, their ratio of pesticide expenses to total operating expenses suggest that this group relied more on chemical control to manage their onion pests, even though their pest problems were no more severe than the two other groups of respondents (all groups reported the severity of their pest problems as only moderate). Pesticide cost in Bongabon was 22 % of total costs compared to only 12 % in San Jose and Munoz (figure V.6).

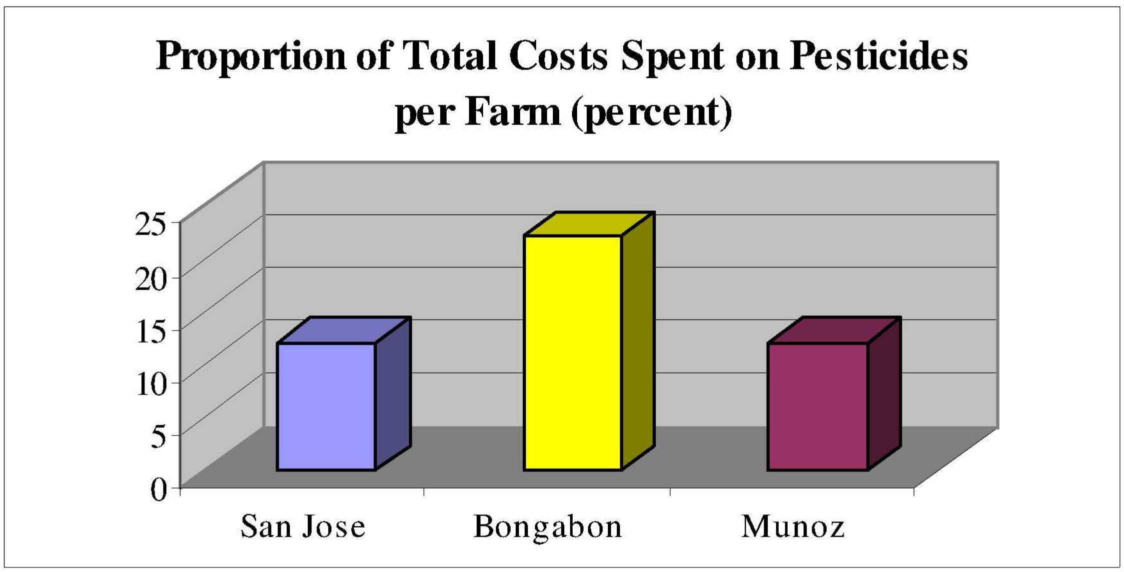

Figure V.6. Proportion of Total Costs Spent on Pesticides among Farmers in San Jose, Bongabon, and Munoz, 1996-1997 Onion Season

Treating seeds with nematicides and fungicides before planting was another common chemical control measure. Field monitoring and some form of scouting were also used to check the types and densities of pests present. Table V.1 shows the proportion of farmers in each of the sites that practised each of the pest control methods

Table V.1. Pest Control Methods Used for the Rice-Onion System in San Jose, Bongabon, and Munoz, 1996-1997

PEST CONTROL METHODS USED [a]	SAN JOSE n=110	BONGABON n=30	MUNOZ n=36	AVERAGE n=176
Pesticide Application	100	100	100	100
Use of Treated Seeds	41	87	42	51

Scouting/Field Monitoring	41	30	47	40
Passive Monitoring Devices	19	30	6	19
Use of Resistant Varieties	22	0	14	16
Use of Beneficial Insects	16	0	9	11
Crop Rotation	11	3	0	7
Water Treatment	2	13	8	6

[a] Numbers in the table represent percentage of responses

Pest Control Decision Factors

The farmers' main source of information about the effectiveness of pest control strategies were other farmers (as reported by 69 % of the respondents). Pesticide sales agents were also influential in that as much as 43 % of the farmers reported to get pest control advice from this source. Other sources of pest control information were the Department of Agriculture technicians, farmers' cooperatives, and IPM experts.

Table V.2. Percentage Responses about Source of Pest Control Advice by Site

SOURCE OF PEST CONTROL ADVICE (nos. represent % responses)	**SAN JOSE** n=110	**BONGABON** n=30	**MUNOZ** n=36	**AVERAGE** n=176
Another Farmer	66	63	83	69
Dept. of Agriculture-Technicians	49	13	3	33
Cooperatives	18	67	14	27
Pesticide Sales Agents	41	57	36	43
IPM Training	9	100	6	31

The respondents' pesticide choices were determined by considering the type of pests present, and pest densities. The price of the pesticide and consideration of its toxicity also influenced their choices. Some farmers followed a regimen such that their pesticide choices and usage were fixed regardless of changing field and pest conditions, and so other factors listed in Table V.3 did not affect their pest management decisions.

Table V.3. Percentage Responses by Decision Factor

DECISION FACTORS	**SAN JOSE** n=110	**BONGABON** n=30	**MUNOZ** n=36	**AVERAGE** n=176
Type of Pest	91	100	92	93
Pest Density	86	100	97	91
Price of Pesticide	75	97	71	78
Toxicity of Pesticide	68	100	83	77
Follows a Pest Control Regimen	72	90	74	76

Knowledge of IPM in the Region

The majority of the farmers in the study had no knowledge of integrated pest management concepts. One-third of the respondents had limited awareness about integrated pest management. Of the 176 farmers interviewed, only 16 % had some form of IPM training, 12 % adopted IPM practices learned from the training, and 13 % reduced pesticide application after the training. Aside from IPM training courses, knowledge about IPM concepts were derived from other farmers by word of mouth (34 %) and from PhilRice staff (20 %).

Table V.4. Knowledge of IPM Concepts among the Survey Groups

KNOWLEDGE OF IPM (numbers represent % of responses)	**SAN JOSE** n=110	**BONGABON** n=30	**MUNOZ** n=36	**AVERAGE** n=176
Heard about IPM	35	20	17	28
Considers IPM an Important Issue	33	20	17	27
Attended IPM Training	21	10	8	16
Attended Farmer Field School	17	7	8	13
Adopted IPM Practices Learned	14	10	11	12
Reduced Pesticide Use After	16	7	11	13
SOURCE OF IPM KNOWLEDGE				
Other Farmers	43	0	40	34
Training/Seminars	42	60	60	49
Extension Agents	8	0	20	9
Ads:Television/Radio/Fliers	10	0	0	6
PhilRice Staff	7	20	60	20

Perceptions about the Environmental Impacts of Pesticide Use

Awareness about the hazards of pesticide use on the different impact categories was high. At least 75 % of the respondents believed that pesticides have an effect on human health, fish, beneficial insects, and farm animals. In fact, about 25 % of the farmers reported to have experienced being sick after spraying pesticides. They reported to have felt the following symptoms of pesticide exposure: dizziness, nausea, chills, stomach pain, numbness of the mouth area, skin rashes, runny nose, fatigue, head ache, and sore eyes. Also, one-fifth of the respondents noticed diminished fish populations and pest resurgence after pesticide applications.

Table V.5. Onion Farmers' Perceptions about Pesticide Impacts

PERCEPTIONS ABOUT PESTICIDE IMPACTS	SAN JOSE n=110	BONGABON n=30	MUNOZ n=36	AVE n=176
Do pesticides affect the following?	(percentage of "yes" responses)			
Human Health	87	100	94	91
Beneficial Insects	71	100	86	80
Fish and other Aquatic Species	66	97	75	74
Avian Species	38	67	66	49
Mammalian Farm Animals	71	100	81	79
Importance of Risks to:	(% of "very important" responses)			
Human Health	99	100	100	100
Fish and other Aquatic Species	63	73	64	65
Avian Species	36	30	39	35
Mammalian Farm Animals	77	83	78	78
Beneficial Insects	63	63	58	62
Experiences and Observations	(% of responses)			
Got sick from pesticide spraying	27	21	22	25
Noticed pest resurgence after spraying	24	12	22	21
Observed farm animal-poisoning	11	0	6	8
Noticed fish kills due to pesticides	27	4.2	19	21
Noticed bird kills due to pesticides	6	5	3	5

Respondents' views or perceptions on the importance of risk avoidance varied depending on the impact category. Most of the farmers felt that reducing the risks of pesticides to birds was not a very important concern, mainly because birds were considered rice pests. Ranking of the five impact categories according to degree of importance was consistent across the three groups of respondents. The following table shows the ranking results in decreasing order of importance.

Table V.6 Order of Importance of the Five Impact Categories

CATEGORY	RANK
Human Health	1
Farm Animals	2
Fish and other Aquatic Species	3
Beneficial Insects	4
Birds	5

Farmer Characteristics

The comparison of mean values across the three groups of respondents showed no significant differences in terms of personal or farmer characteristics. The only marked difference was the land tenure status of the farmers in Bongabon, where eighty percent (80 %) were owner-operators. In San Jose and Munoz, at least a third of the respondents were leasing the farmlands they operated.

Only 11 percent of the respondents were females. Because of the very limited number of females in the sample further analysis considering gender differences can not be explored.

The average farmer-respondent was about 46 years old, with 19 years of farming experience, 8 years of formal education (6 years of elementary- and 2 years of high school education), and an average of 21 hours of work on the farm per week.

Table V.7 Personal Attributes of Onion Farmers in San Jose, Bongabon, and Munoz, 1997-1998 Producer Survey

PERSONAL ATTRIBUTES (numbers represent mean values)	**SAN JOSE** n=110	**BONGABON** n=30	**MUNOZ** n=36	**AVERAGE** n=176
Age (years)	45	49	45	46
Farming Experience (years)	19	22	18	19
Educational Attainment (years)	8	9	9	8
Time Spent On-Farm (hours/wk)	22	20	18	21
Tenure Status (numbers represent % responses)				
Owner-operator	55	80	61	61
Leasee	42	17	33	35
Tenant	3	3	6	4
Gender (% of Females)	7	27	8	11

Indicators of Pesticide Exposure

Several questions about the respondents' immediate farm environment and the precautionary measures they take against pesticide exposure were incorporated in the survey to assess the degree of environmental risks in the area.

Surface waters in the region were at risk from pesticide runoff. The distance of the onion farms to surface waters ranged from as close as .5 meters to about 400 meters. Fish and other aquatic species that abound in these surface waters - tilapia, gurame, mudfish, catfish, snails, frogs, some shellfish and freshwater shrimp, are at risk due to surface runoff. In fact, incidence of fish kills has been reported in the past. Human ingestion of contaminated fish can not be dismissed as well.

In general, the respondents had very limited protection against pesticide exposure. Only about one-third of the respondents wore face masks (or any substitute), long pants, or long sleeved-shirts for protection, and very few (5 %) of them wore shoes when applying pesticides.

Most of the farmers had wells, about 9 meters deep, as their main source of drinking water. To get an indication of how important it was to farmers to avoid being sick from contaminated water, they were asked whether they boiled their water before drinking. This precautionary practice was however not commonplace.

Table V.8. Indicators of Exposure

PESTICIDE EXPOSURE (**% of "yes" responses**)	**SAN JOSE** n=110	**BONGABON** n=30	**MUNOZ** n=36	**AVERAGE** n=176
Do you boil your drinking water?	4	3	17	6
Do you wear the following?				
Face Mask	22	13	95	35
Long Pants	26	10	89	35
Long Sleeved-Shirts	20	10	94	33
Shoes	3	0	17	5
Ave. Depth of Water Wells (meters)	8	11.5	8.2	9
Distance between Surface Waters and Onion Fields (meters)	34	20	6	26

Summary of Survey Results

Personal attributes were very similar in the three different sites surveyed. However, there were differences in pest management practices, particularly between the Bongabon group and the San Jose and Munoz groups. The Bongabon farmers' use of pesticides was considerably higher compared to the two other groups.

Awareness about alternative measures of pest control was evidently lacking among the farmer respondents. This lack of awareness was made apparent by their over reliance on chemicals to control onion pests and diseases. Pesticide spraying was the primary pest management strategy in all of the study sites. Simple cultural pest control measures like water treatment, most effective against thrips, were only being practised by a handful of farmers. Awareness about the usefulness of beneficial insects was highest in the San Jose group, which hopefully could be attributed to the presence of IPM-CRSP in the area. Knowledge about integrated pest management however, even in the IPM-CRSP sites, was very limited. Fortunately, willingness to adopt alternative pest control strategies such as reduced herbicide treatments, rice hull burning, rice straw mulching, and biological controls was quite high among the farmers. This willingness to try more environmental friendly practices may have been motivated by their perceptions and beliefs about the harmful environmental impacts of pesticide use. It was also a common belief that IPM could substantially reduce their operating expenses. Although farmer respondents generally knew about the risks that pesticides posed to the different categories, there seemed to be no conscious effort in their part to exercise precautionary measures against pesticide exposure and prevent environmental degradation.

The Bongabon farmers, generally the more affluent group, had a comparative advantage in their onion operations over other groups because of larger farm sizes, higher quality onion varieties, access to credit, and marketing tie-ups. Hence, more income was generated from onion production in Bongabon compared to San Jose and Munoz, where rice was still the main source of income. The Bongabon group was more exposed to different cultural methods of pest control through training and seminars. It was relatively easy to facilitate such technology transfer programs in Bongabon because of the highly organized nature of the group. Establishment of farmers' cooperatives therefore may have positive implications for IPM adoption.

Results of the Evaluation of the IPM Program in the Philippines

The following section summarizes the results from the step-by-step procedure used in evaluating the benefits of the IPM CRSP in Nueva Ecija.

The Environmental Categories

The selection of the environmental categories for impact evaluation considered the different receptor groups that face hazards from exposure to different pesticide active ingredients and their importance to the farming community. Scientific experiments in the Philippines verify that the 5 categories: 1) human health, 2) beneficial insects, 3) farm animals, 4) fish and other aquatic species, and 5) birds are indeed endangered by exposure to pesticidal ingredients (Pingali and Roger, 1995). Farmers in the area have experienced several symptoms of pesticide poisoning including dizziness, nausea, respiratory problems, among others. In addition, farmers also have observed pest resurgence or secondary pest outbreaks, animal poisoning, bird kills, and fish kills after spraying pesticides on their vegetable fields. These reports indicate the importance and relevance of the five categories in evaluating the impacts of pesticide use and IPM program benefits in the area.

The Pesticide Impact Scores

The impacts/risks posed by the different pesticides used in onions were determined by assigning impact scores or risk scores using the rating scheme/algorithm described in Chapter Three Impact scores for each of the pesticide active ingredients used are provided in Table V.9.

There were three major types of pesticides used by onion farmers: fungicides to control major onion diseases such as damping-off and pink root,; herbicides to prevent weed infestation; and insecticides to control onion thrips, armyworms, cutworms, and maggots. The different pesticides used by onion producers ranged from very low toxicity ratings for bioinsecticides such as Xentari and Dipel to highly toxic active ingredients such as chlorpyrifos and cypermethrin.

The hazard scores ranged from 0 (none toxic) to 5 (highly toxic). The data sources for the different parameters used in the rating scheme are included in the appendix. Hazard rankings from previous studies were used as well as toxicity databases such as EXTOXNET. Some of the toxicity parameters for certain active ingredients were imputed from the average values within their class of active ingredients. For example, if an active ingredient was a member of the pyrethroid class and no data on fish toxicity was available, the average fish toxicity for the pyrethroid class was used for that particular active ingredient. There were a few formulations such as Tordon 101, Vindex Plus, Fenom D, and Nurelle D that were composed of two different active ingredients. The hazard scores were derived by multiplying the hazard for each active ingredient with its concentration or percentage of active ingredient in the formulation. The formulation Vindex Plus, for example, has 70% phenthoate active ingredient with a toxicity score of 3 and 30% BPMC with a hazard score of 5, hence the overall hazard score was calculated as $.3 * 5 + .7 * 3 = 3.6$.

Table V.9 Risk/Impact Scores of Onion Pesticides used in the Study Area by Environmental Category

ACTIVE INGREDIENT	ENVIRONMENTAL CATEGORY				
Fungicides	**Human**	**Animals**	**Birds**	**Aquatics**	**Beneficials**
Benomyl	4	4	3	5	5
Captan	5	5	0	3	3
Copper Hydroxide	3	3	3	3	3
Copper Oxychloride	3	3	3	3	3
Cupric Hydroxide	3	3	3	3	3
Mancozeb	3	3	3	5	5
Mn-Zn Ethylene	3	3	3	5	5
Propamocarb	3	3	3	3	3
Thiophanate Methyl	1	1	3	4	5
Herbicides					
2,4-D IBE	3	3	3	4	5
Bentazon	3	3	1	3	5
Butachlor	3	3	1	3	3
Fluazifop-P-Butyl	4	4	0	5	5
Glyphosate	4	4	3	3	3
Isopropylamine	3	3	1	3	3
Oxadiazon	3	3	1	3	3
Oxyflourfen	4	4	1	5	5
Picloram + 2, 4-D	3	3	3	4	5
Insecticides					
Acephate	1	1	5	1	3
Bacillus Thuringiensis	2	2	0	0	0
Carbaryl	2	2	3	4	5
Carbofuran	3	3	5	3	5
Cartap HCL	3	3	3	5	5
Chlorpyrifos	3	3	5	5	5
Chlorpyrifos + BPMC	3	3	5	5	5
Chlorpyrifos + Cypermethrin	3	3	5	5	5
Cypermethrin	4	4	1	4	5
Deltamethrin	4	4	3	4	5
Diazinon	1	1	5	4	3
Diazinon + Cypermethrin	4	4	5	4	3
Ethofenprox	3	3	3	1	1
Fenvalerate	3	3	1	5	5
Fipronil	3	3	3	1	1
Lambdacyhalothrin	3	3	3	4	5
Malathion	4	4	3	3	5

Methamidophos	4	4	5	2	5
Methomyl	3	3	5	4	3
Methyl Parathion	4	4	5	4	3
Monocrotophos	4	4	5	3	5
Phenthoate	4	4	3	4	3
Phenthoate + BPMC	4	4	3	4	3
Profenofos	4	4	5	2	5
Thiodan	3	3	3	4	1
Triazophos	3	3	3	3	3

Willingness to Adopt IPM CRSP Technologies

The success of a program such as the IPM CRSP can be guaranteed only if there is widespread adoption of these technologies. The reason for actual farmer field trials is to promote a participatory or grassroots approach to IPM research ensuring that farmers get as much exposure and awareness about their pest control alternatives. Hence, the survey included a section on respondents' willingness to adopt IPM CRSP technologies.

A brief introduction was given to all of the respondents stating that alternative ways of controlling pests were being tested by a group of scientists from the states, IRRI, and PhilRice, and that their primary concern was to come up with better ways to control insect pests, weeds, and other secondary pests, that could possible reduce the harmful effects of pesticides to human health and the environment while maintaining or even enhancing onion yields. Each of the experiments was explained carefully, comparing the experiments with known farmers' practices. Then each respondent was asked the question: "*if IPM CRSP technology x were to become available next year, are you willing to adopt this technology or not?*" The following table shows the proportion of farmers in each of the sites who indicated willingness to adopt IPM CRSP technologies. The reduced-chemical strategies (ONEHERB and TRIWKLY) have 94% likelihood of adoption based on willingness to adopt responses. The RHULL only has 36% chance of adoption, while the CASTOR and VIRUS technologies will likely be adopted by 50% and 45% of the survey respondents.

Table V.10. Farmers' Willingness to Adopt IPM CRSP Technologies in San Jose, Bongabon, and Munoz, 1997-1998 Survey

IPM CRSP TECHNOLOGY	SAN JOSE n=110	BONGABON n=30	MUNOZ n=36	AVERAGE n=176
RHULL	53	4	51	36
CASTOR	51	40	60	50
VIRUS	49	32	53	45
ONEHERB	90	93	100	94
TRIWKLY	93	97	91	94

While these values are used to calculate the program benefits in the survey area, it was deemed necessary to estimate econometric models that can predict adoption rates based on relevant causal variables to allow the benefits of the program to be projected to a much larger sample or population in the future, given information on average values for general socio-economic attributes of onion producers in the region. Moreover, the analyses provided insights on the magnitude and direction of influence of the different socio-economic factors affecting willingness to adopt. *SAS System for Windows Version 6.12* and *Limdep (Version 7)* were used for the statistical analyses. Logistic regression allowed for the probabilities of adoption to be predicted more efficiently by using additional information embedded in the set of covariates used in the model.

The probabilities of adoption for the two reduced chemical control strategies, namely: 1) change in frequency of Brodan (insecticide) application from once a week to once in three weeks (TRIWKLY); and 2) 50% reduction in herbicide treatments (ONEHERB), were not estimated using the regression techniques described in Chapter Three because of lack of variation in the dependent variable. Very few farmers (11 for TRIWKLY and 12 for ONEHERB) indicated non-willingness to adopt the two IPM CRSP strategies. In contrast, 93% (94%) of the producers reported willingness to adopt TRIWKLY (ONEHERB) implying an overwhelming acceptance[25] of a reduced-pesticide strategy. With such disproportionate values for the two binary dependent variables-- less than 10% non-willingness-to-adopt responses, goodness-of-fit of the models was questionable and convergence to the coefficients' maximum likelihood estimates was not

[25] The overwhelming acceptance of this reduced-chemical strategy is driven by farmers' beliefs that onion yields and pest infestation levels will not be made worse by this alternative.

possible. Regression models were estimated for three IPM CRSP technologies, namely: RHULL, CASTOR, and VIRUS models

Data Issues

There is an issue of whether the set of respondents (the sample) selected for the survey is representative of the general characteristics of the population of farmers in the area. Considering that the estimated probabilities are predicted using farm and farmer attributes and that these estimated probabilities are used to project adoption rates across the region, it is worthwhile to ensure that the sample is not expected to result in any form of sample bias. The statistical test for this involves comparing the mean values of some general farm and farmer characteristics with population values or sample means from a bigger sample drawn from the same set of respondents. Attributes like age, educational attainment, farm size, and yields of the sample of 176 farmers were compared with the mean values for the same variables from a sample of 300 farmers (1994 baseline survey) drawn from the same population of San Jose farmers.

Table V.11. Mean Values of General Socio-Economic Attributes: 1994 Baseline Survey and 1997 Producers' Survey

VARIABLE	1994 BASELINE SURVEY (n=300)	1997 PRODUCER SURVEY (n=176)
AGE (# of years)	46.3	45.8
EDUCATION (years of schooling)	7.9	8
TOTAL FARM SIZE (hectares)	1.43	1.6

The analysis of means showed that the average values for age, years of schooling, yield, and farm size for the 1994 baseline survey and the 1997 producer survey are equal (see attached for SAS output/test results). The evidence therefore reveal that the set of respondents selected is a representative sample of the farmer population in the IPM CRSP areas and this sample is not expected to cause sample bias.

Correlation analysis was also done to check for possible collinearity among the covariates. As expected, the correlation coefficients (pearson) for yield and income (0.62), farm size and income (0.65), farmsize and yield (0.65), farming experience and age (0.8), heard of IPM and attended IPM (0.7) indicated significant correlation between these pairs of regressors. The *farming experience* and the *attend* variables were dropped from the model and the PSHARE variable was used to capture income effects. All the other pairs of explanatory variables had reasonable pearson correlation coefficients. Missing values associated with the regressors reduced the number of observations to 152.

Factors Affecting Willingness to Adopt IPM CRSP Technologies

Influence of the explanatory variables on the adoption of IPM CRSP technologies is shown in TableV.12. Logit regression results for the RHULL model revealed that being an owner-operator and spending more hours on the farm per week negatively affect willingness to adopt rice hull burning as an alternative control for weeds and nematodes. The coefficient for Bongabon variable also turned out to be negative. One possible explanation for this result could be the difficulty for this region to obtain and transport the rice hull material to the onion fields (especially for producers whose major crop is the onion). This was pointed out by a few Bongabon farmers during the survey. There were no significant variables that increased the probability of RHULL adoption.

The probability of adoption of the CASTOR technology is increased when farmers are more aware of IPM concepts (HEARD), if they have personally witnessed any one of the environmental impacts of pesticide use, and if they use more precautionary measures against pesticide exposure. On the other hand, receiving pest control advice from fellow farmers, being from Munoz, and working more hours on the farm per week have a negative effect on willingness to adopt CASTOR.

For the VIRUS model, nine variables were found to significantly affect willingness to adopt Bt and NPV technologies. The dummy variables representing Bongabon and San Jose were not significant in thus model These results indicate that at the time of the survey the demonstration plots (located in these two sites) had no enhancing effects on technology diffusion. Three of the five information variables significantly explained adoption of the VIRUS technology. Interestingly, contrary to its hypothesized effect, the influence of pesticide sales agents on the probability of Bt and NPV adoption was positive. The microbial agent *Bacillus thuringiensis* is however the active ingredient present in two commercially available biological insecticides (Dipel and Xentari); and marketing efforts for the Bt insecticides in the area could indirectly cause this positive relationship. Pest management information obtained from DA technicians had a negative effect on the adoption of this technology, while getting pest management information through farmers' cooperatives increased the probability of adopting the technology. The organized structure of farmers' cooperatives is valuable attribute that aids in information dissemination. In the same manner, the extensiveness of the marketing channels placed by pesticide companies makes them a formidable influence in farmers' pest management decisions.

Awareness about IPM (HEARD) and the impacts of pesticides on the environment (OBSENV), as well as the amount of care taken avoid exposure all had a positive influence on the dependent variable. As expected, farmers who worked off-farm and owned larger farms were more likely to adopt the technologies.

The marginal effects of the significant variables as well as their odds ratios are also reported in Table V.12. The odds ratio, computed by exponentiating the parameter estimate for each explanatory variable, indicates the factor by which the odds of the event is increased or decreased. Results for the CASTOR model show that the odds for adoption is significantly increased by a unit increase in the PREVENT, OBSENV, and HEARD variables. This implies that increasing farmers' awareness of the health and environmental impacts of pesticide use and their knowledge of integrated pest management are very important in promoting adoption of alternative pest management practices. For adoption of Bt and NPV, factors that represent scale of operations and flexibility of farmers to experiment and try new practices increase the odds of adoption (OWNER, FARMSIZE, and OFFWORK) by a factor of 2. Like in the CASTOR model, awareness variables had a significant impact in increasing the odds of adoption. In addition, cooperatives and pesticide sales agents are important change agents. Collaboration among the different change agents (extensionists, pesticide agents, and farmer cooperatives) for technology promotion should be advocated.

Table V.12. IPM CRSP Willingness to Adopt Models: Logistic Regression Results

A. THE RHULL MODEL

VARIABLE [a]	PARAMETER ESTIMATE	MARGINAL EFFECTS	ODDS RATIO
INTERCEPT	1.858	0.432	--
AGE	0.001	0	1.001
EDUCATION	0.048	0.011	1.050
OWNER**	-0.948	-0.220	0.387
FARMSIZE	0.053	0.012	1.054
PSHARE	-0.506	-0.118	0.603
OFFWORK	-0.243	-0.056	0.784
PCTCOST	-0.856	-0.199	0.425
PREVENT	-0.196	-0.046	0.822
SPCF	-0.054	-0.012	0.948
SPCDA	0.055	0.013	1.056
SPCCOOP	0.230	0.053	1.259
SPCAGENT	-0.436	-0.101	0.646
SPCTRAIN	-0.521	-0.123	0.594
BONGA*	-3.233	-0.751	0.039
SAN JOSE	0.216	0.050	1.241
SICK	0.164	0.038	1.179
OBSENV	0.112	0.026	1.119
HEARD	0.104	0.024	1.109
FARMHRS**	-0.034	-0.008	0.967

[a] Variables that significantly affect the dependent variable are noted with asterisks; * indicates the variable is significant at $\alpha = 1\%$, ** for 5 % level of significance, *** represents 10% level of significance, and **** represents 15% level of significance.

B. THE CASTOR MODEL

VARIABLE	PARAMETR	MARGINAL	ODDS
INTERCEPT*	-10.320	-2.568	--
AGE	0.015	0.004	1.015
EDUCATION	0.076	0.019	1.079
OWNER	0.072	0.018	1.074
FARMSIZE	0.136	0.034	1.146
PSHARE	0.313	0.078	1.367
OFFWORK****	0.739	0.184	2.094
PCTCOST	3.137	0.781	23.034
PREVENT*	1.973	0.491	7.189
SPCF***	-0.984	-0.245	0.374
SPCDA	-0.518	-0.129	0.595
SPCCOOP	0.756	0.188	2.130
SPCAGENT	0.488	0.121	1.629
SPCTRAIN	-1.387	-0.345	0.250
BONGA	-0.339	-0.084	0.712
SAN JOSE	-0.070	-0.017	0.932
SICK	0.526	0.131	1.692
OBSENV*	1.848	0.460	6.351
HEARD*	1.506	0.375	4.511
FARMHRS***	-0.030	-0.008	0.970

C. THE VIRUS MODEL

VARIABLE	PARAMETR	MARGINAL	ODDS
INTERCEPT*	-16.181	-3.944	--
AGE***	0.053	0.013	1.054
EDUCATION	0.118	0.029	1.125
OWNER	0.886	0.216	2.424
FARMSIZE**	0.621	0.151	1.860
PSHARE	0.256	0.062	1.292
OFFWORK***	0.924	0.225	2.520
PCTCOST	1.048	0.255	2.853
PREVENT*	2.323	0.566	10.211
SPCF	-0.627	-0.153	0.534
SPCDA***	-1.642	-0.400	0.194
SPCCOOP***	1.440	0.351	4.219
SPCAGENT***	0.977	0.238	2.657
SPCTRAIN	-1.729	-0.421	0.178
BONGA	-1.466	-0.357	0.231
SAN JOSE	0.781	0.190	2.184
SICK	0.990	0.241	2.691
OBSENV*	1.538	0.375	4.655
HEARD**	1.303	0.317	3.679
FARMHRS	-0.023	-0.006	0.977

Goodness of Fit Measures

The likelihood ratio tests indicate that the amount of variation explained in each of the models is significantly different from zero. Two criteria for goodness of fit are reported in the table, the –2LogL and Score statistics. The χ^2 values for both measures were highly significant (99% confidence level), providing evidence that the regression coefficients were significantly different from zero.

Several measures of the predictive accuracy of the models are provided. Table V.13. The count R^2 is a ratio of the number of correct predictions to the total number of observations. Count R^2 values for the three models (.71 for the RHULL model, .84 for the CASTOR model, and .88 for the VIRUS model) suggest that the selected regressors are good predictors of adoption and non-adoption of IPM CRSP technologies. The proportion of correct prediction compares the correct predictions of both adoption and non-adoption with the observed outcomes based on explanatory variable information. Results for this show that the RHULL Model correctly predicts 68% of adoption cases and 73% of non-adoption cases. For the other two models, 84% (CASTOR) and 86% (VIRUS) adoption cases were correctly predicted, while non-adoption were correctly predicted for 84% (CASTOR) and 89% (VIRUS) of the observations. The strong predictive ability of each of the models in estimating the probabilities of adoption provides justification for using these probabilities to project adoption rates in the area.

TableV.13. Goodness-of-Fit Measures/Predictive Ability of the Logit Models

Measure of Goodness of Fit		**LOGIT MODELS**		
		RHULL	CASTOR	VIRUS
% Correct Predictions:				
Adoption		68	85	86
Non-Adoption		73	84	89
Count R^2		71	84	88
-2 Log L	χ^2 value	45.450	89.707	103.931
	p-value	0.0006	0.0001	0.0001
Score	χ^2 value	37.286	68.966	75.285
	p-value	0.0073	0.0001	0.0001

Estimated Adoption Rates based on Logistic Regression

Table V.14 below shows the estimated adoption rates for each technology in each of the sites based on the logistic regressions. The logit models estimate the predicted probabilities of adoption for each farmer. If the predicted probability of adopting a particular technology for an individual given his or her specific set of attributes, is greater than his or her probability of non-adoption (greater than 50% predicted probability of adoption), the individual is classified as an adopter; otherwise he/she is classified as a non-adopter of that technology.

Table V.14. Predicted Adoption Rates by Site

SITE	IPM CRSP Adoption Rates (percent)		
	RHULL	CASTOR	VIRUS
San Jose	65	43	25
Bongabon	0	36	50
Munoz	39	58	40

Estimated Reduction in Pesticide Use as a Result of IPM CRSP Technologies: Experiment Results

IPM CRSP scientists in the Philippines gathered evidence on the efficacy and yield effects of the different IPM CRSP technologies. More importantly, the impacts of these technologies on pesticide use patterns were examined.

The experimental results show that the technologies are indeed viable alternatives to chemical control measures. There were no significant differences in onion yields among the treatments (chemical control vs. IPM CRSP technologies) and IPM was just as effective as chemical treatments in controlling weeds, insects, and onion diseases. In some instances, yields were higher for the IPM-managed plots.

The experiment on thrips control (the TRIWKLY strategy) found that a reduction in the frequency of insecticide application from once a week to once in three weeks is optimal. This result implies that the use of insecticides for thrips control can be reduced by two-thirds (67%). Furthermore, the results also indicate that if the thrips population is below the threshold level of 10 per plant, no insecticide treatment is needed, thereby possibly reducing insecticides used for thrips control by as much as 100 %.

The ONEHERB experiment revealed that herbicide usage could be reduced by 50%, since additional herbicide treatments do not provide any incremental benefits in terms of weed efficacy and onion yields.

The results for the Bt and NPV experiments (Virus technology) showed that the microbial agents- Bacillus thuringiensis and nuclear polyhedrosis virus were effective in controlling *lepidoptera* spp. (worms) and that there were no significant changes in onion yields. As soon as this technology becomes widespread, it is expected that a 100% reduction in insecticide use is possible.

The RHULL technology was found to be an effective alternative for control of nematodes, onion diseases, and weeds. The CASTOR plant also proved to be effective in attracting insects/worms making it a useful trap plant. The experiments for these two technologies are still on-going and several more trials will be needed to determine exactly how much reduction in pesticide use is possible.

For purposes of evaluating the impacts of the program, assumptions on the combined effects of this mix of technologies on the percentage reduction in pesticide usage had to be made, especially since it is impossible to determine at this point whether the impacts are additive, synergistic or even whether adopters view these technologies as substitutes for one another. When actual adoption data becomes available, econometric estimation of effects of adoption of bundled technologies on pesticide usage can be further analyzed.

The farmers that were classified as adopters (from the previous step) were identified, and information on their current consumption of fungicides, herbicides, and insecticides were used to determine the actual amounts of pesticide reduction that can be induced by the program. Since the IPM CRSP technologies target different onion pests, each technology had different impacts in terms of the type of pesticide that can be reduced. Hence, the analysis was done by segregating the impacts of the technology package on each of the following: 1) fungicide use, 2) herbicide use, and 3) insecticide use.

Adoption of both the ONEHERB strategy and the RHULL technology affects herbicide use patterns. Since results show that only 50 % of current herbicide usage is needed and that rice hull burning also effectively prevents weed growth and survival, their combined effects were estimated to total 65 % reduction in the amount of herbicides used. The assumption is made that an additional 15% reduction is possible with adoption of the RHULL technology. It was proven though that weed fresh weight was reduced by 88% with rice hull burning.

In terms of impacts of the program on insecticide use—there were three technologies considered, the CASTOR technology, VIRUS technology, and the TRIWKLY strategy. Different insecticides are used, however, for different target pests. To incorporate this issue in the analysis, information on specific pests that are being targeted by each pesticide formulation and their corresponding active ingredients were gathered. Most of the insecticides used in onions control thrips, cutworms, armyworms, and maggots. Since insecticide treatments for thrips control can be reduced by 67%, all insecticides that were being used to control thrips were identified and reductions in usage were calculated accordingly. Similarly, insecticides used to control worms were identified, and with CASTOR and VIRUS adoption, at least 50% reduction in dosage is allowed. To avoid double counting, insecticides that control both thrips and worms were not reduced twice as a result of TRIWKLY adoption and CASTOR-VIRUS adoption, instead dosage reduction attributable to both sets were reduced by 50%.

Calculations for program impacts on fungicide use reduction were calculated in a similar manner. Only one technology however affects fungicide use; the RHULL technology was assumed to induce a modest 25% reduction is dosage. The actual reductions in pesticide dosage by type of use are provided in the Appendix.

Using the different impact scenarios for each technology and pesticide usage of predicted adopters for each technology, the following results were derived:

TableV.15. Reduction in Amount of Active Ingredient by Technology

IPM CRSP STRATEGY /	% Reduction [a]	Reduction in Amt of AI (kgs)
ONEHERB (herbicides)	50	43.33
TRIWKLY (insecticides)	67	118.89
	100	177.44
VIRUS (insecticides)	100	151.83
CASTOR (insecticides)	25	29.28
	50	58.55
	75	87.83
RHULL (fungicides)	25	1.90
	50	3.80
	75	5.69
RHULL (herbicides)	25	4.28
	50	8.55
	75	12.83

[a] The numbers represent different possibilities or scenarios of the percentage reduction in insecticides, herbicides, and fungicides that each IPM CRSP technology can possibly induce

Estimation of Society's Willingness-to-Pay for a Reduction in the Risks Posed by Pesticides to the Five Environmental Categories

Society's willingness to pay (WTP) for environmental improvements or risk avoidance provides the means to place a monetary value on the environmental benefits of the IPM CRSP in Nueva Ecija. WTP values were obtained by using the contingent valuation method (CVM). The consensus these days is that using CVM to measure the benefits of less familiar goods such as risk reductions of pesticide use to different environmental categories is difficult. However, provided the respondents can be motivated to carefully follow the contingent market described in the scenario and find it sufficiently plausible, CV surveys do offer the possibility of obtaining meaningful information about consumer preferences for non-market commodities (Mitchell and Carson, 1989). The main challenge faced was to make the scenario sufficiently understandable, plausible, and meaningful to the respondents so that they could give valid and reliable values. One of the indicators of reliability of WTP bids is for the values to be within their budgets (household income), which should prove their ability to pay. The mean values for WTP values for the five categories were well within their budgets posing no problems on ability to pay.

The bids were elicited by simulating a buy and sell exercise quite familiar with the farmers. Respondents were asked to place their WTP values to buy different formulations of their favorite pesticides. Five different formulations were offered: 1) one that avoids human health risks; 2) one that prevents risk to birds; 3) one that prevents risk to fish and other aquatic species; 4) one that prevents risk to farm animals; and finally 5) one that prevents risk to beneficial insects.

The willingness-to-pay bids were estimated using ordinary least squares in order to incorporate additional information embedded in the choice variables and to check for consistency with economic theory. In addition, this multivariate regression model allows for projection of results to a larger group given more information on the choice variables.

The variables included in the models (Table V.16) were: income, age, educational attainment, share of pesticide expenses in total operating costs, degree of importance of human health, beneficial insects, farm animals, birds, and aquatic species, observations on the following environmental consequences of pesticide use—secondary outbreaks, farm animal poisoning, bird kills, fish kills, as well as a variable sick indicating the individual has experienced being sick from pesticide use.

Table V.16. Summary Statistics for the Choice Variables in the WTP Models

VARIABLE	DEFINITION	Mean	Std. Dev'n
RETURNS	returns from farming (1996-1997 season) pesos	72,910	119.41
COST	% of pesticide costs to total operating expenses	0.14	0.09
AGE	number of years	45.86	12.61
EDUC	educational attainment, number of years	7.99	3.0
Degree of importance of risks to the 5 categories (scale of 1-3, 1= most important):			
IMPTH	importance of impacts on human health	1	0.15
IMPTF	importance of impacts on fish/other aquatics	1.36	0.5
IMPTB	importance of impacts on birds	1.72	0.6
IMPTFA	importance of impacts on farm animals	1.22	0.46
IMPTBI	importance of impacts on beneficial insects	1.39	0.53
Experience on Pesticide Impacts (0/1):			
SICK	experienced symptoms of poisoning	0.256	0.44
RESURGE	observed secondary pest outbreaks	0.23	0.42
PPOISON	observed farm animal poisoning	0.09	0.29
FKILLS	observed fish kills	0.24	0.43
BKILLS	observed bird kills	0.08	0.27
Exposure parameters			
EATFISH	(0/1):consumes fish from nearby surfacewaters	0.31	0.46
EXPOSE	amount of care taken to prevent exposure (1-5)	2.74	0.89

Table V.17. shows the mean and standard deviation of the willingness to pay bids of the farmer respondents for each of the environmental categories

Table V.17. Summary Statistics for the Dependent Variables

VARIABLE	Mean WTP (pesos)	Standard Deviation
WTP: Human Health	680	219
WTP: Beneficial Insects	580	197
WTP: Fish and other Aquatics	577	200
WTP: Birds	551	198
WTP: Farm Animals	621	210

The influence of the choice variables on willingness to pay estimates for each of the environmental categories are reported in Table V.18.

The income variable (RETURNS) was consistently significant in all of the models except for the human health model. The implication is that all the other environmental categories (birds, beneficial insects, fish, and farm animals) can be viewed as normal goods-- as income increases demand for such goods increase. This result is consistent with what consumer theory suggests.

The COST variable came out significant and positive in the beneficial insects model, the birds model, and the human health model. This result suggests that as the relative share of pesticide expense increases relative to total operating expenses, willingness to pay for risk avoidance to these three categories increases. This result does not contradict economic theory. As farmers use more pesticides, concern for the environment and effects on human health increases. This may be driven by the fact that most farmers are risk averse because of their heavy reliance on the farming business for their livelihood and pesticide usage gives them some assurance that crop damage can be avoided. Without any known reliable and safer alternatives to chemical control, pesticides would still be their main method of controlling pests despite the fact that they worry about the environmental consequences of their actions.

The only other variable that significantly explains willingness to pay for human health is having observed fish kills in nearby surface waters. The survey results indicated that the fish from these sources are a major part of farmers' daily diets. Hence, concern for ingesting pesticide-laced fish motivates this behavior. The degree of importance variables for avoiding risks to beneficial insects, farm animals, and fish species are negative—this implies that the more importance they place on avoiding impacts, the higher their willingness to pay values. In addition, first hand knowledge of environmental effects represented by the variables RESURGE and FKILLS were significant and positive in the beneficial insects model and the fish model, respectively.

The R^2 values for each of the five models (which ranged from .05 for the birds model to 0.17 for the human health category) are very low. However, considering the cross-sectional nature of the data these values are not too surprising.

Nevertheless, the goodness of fit measures of the five models provide evidence that the overall explanatory power of the model is good. Only the birds model did not get a 15% level of significance, the α-level was 0.18. Hence, the willingness to pay estimates appear to be reliable. These estimated values are combined with reduction in risks calculated using values from steps 2, 3, and 4.

Table V.18. Estimated and Adjusted Willingness to Pay Values for Risk Avoidance by Impact Category

ENVIRONMENTAL CATEGORY	Mean WTP (pesos)	Adjusted WTP (pesos)
Human Health	680	476
Beneficial Insects	580	406
Birds	577	385
Fish and other Aquatic Species	551	404
Farm Animals	621	434

These values represent each respondent's willingness to pay for risk avoidance. However risks from pesticide exposure are being incurred by these people not only from their onion production but also from pesticide use in their rice crops during the wet season. In order to incorporate this, information on mean pesticide usage for each of the crop were obtained (Rola et al.,1995). It was determined that 70% of the total pesticides used by the rice-onion farmers were applied on the onions and 30% for rice. The willingness-to-pay estimates were then weighed by this percentage to account for the value they place on risk avoidance specifically from their onion production.

Table V.19. Willingness to Pay Models: Regression Results

Variable	Parameter Estimate	Pr >|T|	F-Value	Prob>|F|	R^2
Human Health Model			4.267	0.0001	0.17
Returns	0.000157	0.2629			
Age	1.426547	0.2929			
Educ	4.268047	0.4598			
Cost	578.652728	0.0018			
ImptH	-129.074555	0.2163			
Resurge	33.185007	0.4306			
Ppoison	5.698242	0.9267			
Fkills	128.509462	0.0062			
Beneficial Insects Model			2.913	0.0100	0.0947
Returns	0.000260	0.0469			
Age	-0.050531	0.9676			
Educ	-3.451737	0.5189			
Cost	303.117790	0.0747			
ImptBI	-52.750947	0.0562			
Resurge	64.275016	0.0665			

Farm Animals Model			1.774	0.1073	0.0606
Returns	0.000214	.1340			
Age	0.195256	0.8860			
Cost	187.816434	0.3191			
Educ	-8.739520	0.1405			
ImptFA	-71.725445	0.0414			
Ppoison	-16.595446	0.7714			
Aquatics Model			3.358	0.0038	0.1088
Returns	0.000246	.0641			
Age	-0.504854	0.6888			
Educ	-6.663618	0.2263			
Cost	243.481553	0.1567			
Fkills	88.511441	0.0139			
ImptF	-63.921172	0.0333			
Birds Model			1.508	0.1783	0.0517
Returns	0.000284	.0362			
Age	-0.179940	.8887			
Educ	-4.200899	.4528			
Cost	261.009129	.1368			
ImptB	-10.427014	.7002			
Bkills	21.404980	.7056			

The Economic Benefits of the Health and Environmental Impacts of IPM CRSP Technologies

This step is a synthesis of the environmental risks, adoption rates, pesticide usage, and willingness-to-pay estimates generated from the first five steps of the evaluation process. The benefits of the program are derived by calculating the impacts of the five IPM CRSP technologies in terms of reducing risks to the five receptor groups--humans, farm animals, beneficial insects, fish and other aquatics, and birds. The premise is that a reduction in pesticide usage decreases the estimated environmental risks to the five receptor groups. The degree of risks that can be avoided with adoption of the technologies is combined with society's willingness to pay for risk avoidance, generating an estimate of the savings attributable to the program. The following table provides values for the environmental risk scores with and without IPM CRSP adoption.

Table V.20. Percentage Changes in Ecological Ratings Induced by the Impact of IPM CRSP on Pesticide Use Patterns for One Cropping Season

CATEGORY	TYPE OF USE	ECORATINGS WITH OUT IPM	ECORATINGS WITH IPM CRSP	% RISK AVOIDED [a]
Human Health	Herbicide	322.66	113.94	64
	Insecticide	404.75	142.15	
	Fungicide	19.98	14.98	
Beneficial Insects	Herbicide	331.70	117.23	61
	Insecticide	456.4	180	
	Fungicide	28.04	21.03	
Fish/other Aquatics	Herbicide	330.59	116.8	62
	Insecticide	358.46	131.5	
	Fungicide	26.64	19.98	
Avian Species	Herbicide	122.29	43.25	6
	Insecticide	404.75	161	
	Fungicide	22.78	17.08	
Farm Animals	Herbicide	322.66	113.94	64
	Insecticide	404.75	142.15	
	Fungicide	19.98	14.98	

[a] The values represent the percentage change in ecoratings with IPM CRSP and without IPM CRSP. The ecoratings for herbicides, insecticides, and fungicides are added together to derive the total ecorating for each of the environmental categories.

Combining the estimated percentage of risks avoided with willingness to pay values for risk avoidance, the estimated benefits of the IPM CRSP in the affected area {projection to a larger population and a larger area is provided in the conclusions} are derived. The total benefits of the IPM CRSP in the affected area is shown as follows:

Table V.21. The Estimated Benefits of IPM CRSP by Category

CATEGORY	% RISK AVOIDED	WTP: RISK AVOIDANCE	BENEFITS (pesos)[a]
Human Health	64	476	305
Beneficial Insects	61	406	248
Birds	60	385	231
Farm Animals	64	434	278
Fish/other Aquatics	62	404	250

[a] These numbers represent values per person for risks reduced per cropping season

The total benefits accrued by farmer residents in the survey area (of 176 onion farmers) total: 230,912.00 pesos. This estimated amount of the benefits of the IPM CRSP, in particular the five IPM CRSP technologies/practices, is based on willingness to pay values of farmer respondents only, and does not include benefits to consumers, hence represent a lower bound approximation to societal benefits.

On top of these savings in environmental costs, the reduction in pesticide use also reduced operating expenses. Calculated reduction in economic costs are provided in Table V.22.

Table V.22. Cost Savings from Adoption of IPM CRSP Technologies

IPM CRSP TECHNOLOGY	**COST SAVINGS Per Season (Expenses on Pesticides, pesos)**		
	Insecticides	Herbicides	Fungicides
TRIWKLY	159,154.00	--	--
CASTOR	149,457.00	--	--
VIRUS	114,940.00	--	--
RHULL	--	17,776.00	1,670.00
ONEHERB	--	123,791.00	--

CHAPTER SIX
SUMMARY AND CONCLUSIONS

There are health and environmental consequences to pesticide use in agriculture. The integrated pest management paradigm came about to address this concern. IPM programs were developed to reduce pesticide use through the use of biological and cultural controls, and by advocating reduced chemical control strategies that are based on specific field conditions and pest infestation levels. While IPM studies have indicated that these alternative strategies help reduce farm costs and maintain or improve crop yields, the benefits to society of such a program go beyond profitability when the health and environmental benefits are considered. These benefits include improved quality of surfacewater and groundwater, food safety for humans and wildlife, health of pesticide applicators, and the long run sustainability of pest management systems.

The IPM-Collaborative Research Support Program (IPM-CRSP) was established specifically to address pesticide misuse in the rice-onion system in Nueva Ecija. The IPM-CRSP activities include research on the optimal use of pesticides, complementary weed control strategies, cultural controls, and biological controls. The goal is to improve farmer income while minimizing pesticide use. If successful, the program should generate benefits that can be measured in economic terms.

The research in this thesis was conducted to establish and test a method for measuring the economic value of the environmental benefits of IPM. The method was applied to IPM practices developed on the IPM CRSP for an onion farming community in Nueva Ecija. The program benefits were derived using a measure of the change in environmental quality attributable to the IPM program and an estimate of society's willingness to pay for this change in quality. The change in environmental quality was measured using an ecological rating score (ecorating). The ecorating with IPM CRSP adoption was compared to the ecorating before IPM CRSP adoption and the percent reduction in scores represented the amount of risks avoided. These ecoratings reflected risks posed by different pesticide active ingredients to five major non-target receptor groups-- humans, beneficial insects, farm animals, birds, and aquatic species. The risks were evaluated using toxicity and exposure indicators as well as usage data.

Results indicate that if the IPM technologies developed on the IPM CRSP are adopted, human health and farm animal risks are reduced by 64%, risks to beneficial insects are reduced by 61%, risks to fish and other aquatic species are reduced by 62%, and risks to birds are reduced by 60%. These estimates are based on adoption rates from observed willingness to pay responses.

To be able to project the benefits of the program to neighboring communities or even to the whole region, the probabilities of adoption of the IPM CRSP technologies were predicted using a maximum likelihood logit model. The adoption model incorporated information on farmer attributes, farm structures, environmental awareness, managerial factors, and perceptions to predict willingness to adopt the technologies. The predicted adoption rates for each technology are: 45% for the RHULL technology, 52% for the CASTOR technology, and 45% for the Bt and NPV technology.

A contingent valuation survey was used to elicit farmers' willingness-to-pay to reduce pesticide risks as measured by their "bids" on various "safer" formulations of their most widely used pesticide. Respondents' mean willingness to pay bids for annual risk reduction to each category are as follows: 476 pesos for human health, 406 pesos for beneficial insects, 385 pesos for birds, 404 pesos for fish, and 434 pesos for farm animals.

Combining willingness to pay bids for risk avoidance and the percentage reduction in risks, the health and environmental benefits of the IPM CRSP for one onion season per affected farmer were estimated to total 1,312.00 pesos. The aggregate benefits to the onion farming community in Nueva Ecija (5 villages) totalled 230,912.00 pesos

Major Contributions

The significance of this study and its major contributions can be summarized by the following:

- Most benefit-cost analyses of IPM programs focus on evaluation of private costs and benefits. This study evaluates an IPM program in terms of its benefit to the environment and human health, thereby going beyond the traditional benefit-cost analysis context.

- There is a great demand for measures of environmental benefits or risks. While several studies have been completed in the United States and other developed countries, studies of this kind are still lacking in developing countries.
- The environmental impact assessment of current pesticide use patterns quantifies the environmental consequences of pesticide use in vegetables. The ecorating scores reflect the risks caused by each pesticide active ingredient to different environmental categories. Using the ecorating scores generated, ranking of pesticide choices or alternatives can be done so that more informed decisions can be made.
- The estimated adoption model provided insights into the factors that influence adoption of different technologies. For example, informational factors such as the source of pest control advice were highly significant in the different models. Results indicate that if pest control advice is obtained through farmer cooperatives, the probability of adoption is increased. In addition, it was found that increasing awareness about the health and environmental impacts of pesticide use among the onion producers raises the likelihood of adoption of IPM CRSP technologies. Hence, educational efforts designed to increase awareness may be worthwhile.
- The adoption model estimated allows for adoption rates to be further projected to a larger community and bigger population given information on average values of general socio-economic attributes of onion producers.
- The CV results indicated that society (particularly those affected by environmental degradation) care about the environmental consequences of pesticide use as WTP bids were positive. The study provides a different valuation/measure of health risks than previous studies which have used avoidance costs, medical expenses, and losses in productivity measures.

Policy Implications

The greatest impact of the benefits of the IPM CRSP will be in the areas of high pesticide use such as Bongabon. Areas like this should be prioritized and targeted by programs and policies designed to push adoption of integrated pest management practices to reduce the region's pesticide use

This study provides justification for public investment of resources in training and educational programs to increase awareness about IPM and promote IPM adoption particularly in areas like San Jose and Munoz. The Munoz group even has an advantage over the San Jose group in that they have been exposed to IPM concepts in rice and some of the practices and beliefs learned from rice IPM are carried over in their onion farming. The Bongabon group on the other hand are proactive and very receptive to try out new technologies and since the cooperative is already investing in training programs and seminars about IPM, price incentives or market-based policies might be the best approach to promote adoption of IPM CRSP technologies. This group of farmers are more likely to react to pricing regulations such as lower priced bioinsecticides (like those containing *Bacillus thuringiensis*) since a substantial portion of their opertaing costs (22%) are spent on pesticides.

Conclusions, Limitations, and Recommendations for Future Research

Practices developed on the IPM CRSP potentially improve environmental quality and reduce farm costs. The IPM CRSP experiments tested for the optimal amounts of insecticide and herbicide application under existing field conditions should be (ONEHERB, TRIWKLY), establishing threshold levels for pesticide use. In addition, cultural and biological techniques were developed that can further reduce chemical applications (RHULL, Bt, NPVB, CASTOR). Field tests and experiments should continue to further establish optimal rules by which pesticide decisions can be based. It is not known for certain how much reduction in pesticide use is possible with the cultural and biological techniques developed under IPM CRSP.

Efforts to transfer these IPM technologies to the farmers more rapidly are needed. Adoption analysis indicated that acceptance by farmers is usually a function of the following:

1) whether producers perceive the innovation to be better than traditional practices;
2) whether the innovations are compatible with traditional and past experiences;
3) whether the innovations are too complex to comprehend and implement;
4) whether the innovation can be tried on a limited basis; and
5) whether the results of the innovation are visible.

The IPM CRSP technologies pass each of these tests so that it should not be difficult to increase adoption. Efforts should begin by increasing awareness about these technologies. The survey revealed that awareness about alternative measures of pest control was lacking, as reflected by farmers' over reliance on chemicals to control onion pests and diseases. Knowledge of IPM, even in the IPM-CRSP sites, was limited even though awareness of the usefulness of beneficial insects and willingness to adopt alternative pest control strategies were high in areas where IPM-CRSP activities are being conducted.

Survey results further indicated producers' willingness to try alternative pest control measures. This willingness may be driven by their perceptions about the adverse impacts of pesticide use and the expected reductions in farm costs if pesticide use is reduced.

The economic success of a highly organized group of farmers makes a good case for espousing establishment of farmers' cooperatives to help hasten IPM technology transfer. The IPM-CRSP technologies can reduce pesticide use in onions without loss of efficacy. For example, results of the IPM-CRSP field trials showed that herbicide use could be reduced by as much as 50% with adoption of the alternative weed control strategies, and a no-insecticide option is viable to control onion thrips if biological controls are used.

One of the limitations of the study was the use of toxicity measures that are based on tests conducted in the states. Also, more specific farm/field conditions (i.e.climatic factors, soil types, etc) should be incorporated in the analysis. If anything, the risk scores derived in this study are lower bound approximations to actual pesticide risks, because use of preventive measures against exposure is not commonplace in the Philippines, and hot and humid conditions prolong pesticide persistence.

With respect to the regression models for predicting adoption, the extent of the bias brought about by omission of variables can not be determined. The model hopefully captured most of the causality. Moreover, adoption could only be predicted based on farmers verbal responses as opposed to actual adoption, because the technologies are still under experimentation.

Further research on the benefits due to IPM in vegetables should be conducted. The benefits calculated in this study are specific to the onion farming community in 5 villages. The health and environmental benefits, however, extend well beyond these farming communities. In addition, benefits to consumers should be estimated. The question is, is there a demand for safer vegetable produce? How much do consumers value IPM-grown produce. If there is a price premium for this safety that consumers would be willing to pay so that incentives could be provided to producers to change their current pesticide use patterns. Finally, as soon as farmers begin to adopt these technologies, impacts on pesticide use can be more accurately estimated. Because different farmers face different constraints or production functions, the reduction in pesticide use from adoption of the technologies may differ from one farmer to another.

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APPENDIX A: THE SURVEY INSTRUMENT

Interview Questionnaire:

Name: ____________________________________ Date: ___________________________

Enumerator: _______________________________

Municipality: ______________________________ Barangay:_____________________

Farm Operations and Characteristics:

1. Have you grown the following in the past 3 years?

	Yes	No
Onions		
Eggplants		

2. What is your total farm size? ____

3. What crops have you planted in the past year (1996-1997) and how many hectares did you use for each crop?

Cropping Season	Crops Planted	Number of Hectares
Wet Season (rice)		
Dry Season (vegetables)		

4. How many parcels of land did you use for onion/eggplant and what were the yields per parcel?

Crop	No. of Parcels	Area per Parcel	Yield per Parcel
Onion Varieties			
Eggplant Varieties			

5. What is the dominant soil type in your farm? ________________________________

6. What is the source of water for your vegetable crops? ________________________

Pest Management Practices

7. How would you describe the severity of your pest problem?

Negligible [ ]   Moderate [ ]   Extreme [ ]

8. What are the most problematic pests?

In onions: ___________________   In eggplants: ________________________

9. *How did you control these pests*? Please check if you practiced any of the following pest management strategies

Pesticide Application	[ ]	Water Treatment	[ ]
Use of Resistant Varieties	[ ]	Use of Treated Seeds	[ ]
Scouting/Field Monitoring	[ ]	Indicate source of seeds__________	
Passive Monitoring Devices	[ ]	Use of Beneficial Insects	[ ]
Crop Rotation	[ ]	Others:________________________	

10. Do you check for presence of pests (insects, weeds, nematodes, etc) before applying pesticides?   Yes [ ]   No [ ]

11. Do you keep records of pest densities, cultural procedures, farm practices, weather factors, or pesticide applications?   Yes [ ]   No [ ]

12. Do you check your sprayer regularly (for leaks and proper calibration)?
Yes [ ]   No [ ]

13. Where did you get pest control advice for your vegetables?

Another Farmer [ ]
DA Technician [ ]
Farmers' Cooperatives [ ]
Pesticide Sales Agent [ ]
Farmer Field School [ ]
Others (Specify)__________________________________

14. What pesticides did you apply on onions/eggplant and kindly indicate amount and frequency of application?

ONION:

PESTICIDE NAME	DOSAGE (ML)	FREQUENCY(PER SEASON)	NO. OF HECTARES

EGGPLANT:

PESTICIDE NAME	DOSAGE (ML)	FREQUENCY(PER SEASON)	NO. OF HECTARES

15. *How much did you spend on chemicals last season? 0nions:* ________ Eggplant:_________

16. What is the most widely used pesticide for your vegetables?

    For Onions:____
    For Eggplant:____

17. What percentage of your total annual operating expenses is spent on pesticides? ________

18. What factors did you consider in deciding when and how much to apply pesticides?

FACTORS	Please Check
Pest density	
Kinds of pests present	
Toxicity of pesticides	
Price of Pesticide	
Calendar Spraying Sked	
Others:	

Knowledge of IPM and Adoption of IPM Practices

19. Have you heard of Integrated Pest Management (IPM)? Yes [ ] No [ ]

20. How would you describe the concept of IPM? ______________________________________
____
____

21. How did you hear about IPM?
    Other Farmers [ ] Fliers [ ]
    IPM Training [ ] Others (specify)____________________
    Extension Agents [ ]

22. Do you think this is an important program? Yes [ ] No [ ]

23. Have you attended any training on IPM before? (indicate if training is on rice-IPM)
    Yes [ ] No [ ]

24. Have you attended a Farmer Field School? Yes [ ] No [ ]

If answer to Q23 and Q24 is No, proceed to Q29.

25. Did you adopt any of the practices or IPM strategies you learned in the training program?

    Yes [ ] No [ ]

26. Describe the IPM techniques you learned in the training program?

    ____

    ____

27. Did you reduce pesticide use after the training? Yes [ ] No [ ]

    By how much did you reduce your pesticide application? ________________________

28. How much of the various pesticides did you use before and after the training?

PESTICIDE NAME	DOSAGE (ML)		FREQUENCY		NO. OF HECTARES
	Before	After	Before	After	

Farmer Characteristics:

29. How many years have you been farming?______________________________

30. What is your age?______________________________

31. What is the highest level of education you attained?________________________

32. How many hours per week do you spend in the farm? ______________________

33. What was your net annual income from the farm business last year? ___________________

34. How much income did you earn from vegetable farming last year? ____________________

35. Do you have other jobs aside from farming? Yes [ ] No [ ]

36. How much income do you earn from other sources? ___________________________

37. What is your tenure status?

Owner-Operator [ ]
Leasee [ ]
Tenant [ ]
Hired Laborer [ ]
Others (specify) ___________________________

Perceptions about the Health and Environmental Impacts of Pesticides

38. In your opinion, do pesticides adversely affect the following categories?

CATEGORIES	Yes	No	Don't Know
Human Health			
Beneficial Insects			
Fish & other Aquatic Species			
Birds			
Farm Animals, Dogs, Cats			

39. Have you ever experienced being sick from pesticide application?

Yes [ ] No [ ]

What exactly did you feel? ____

40. Have you ever noticed incidence of pest resurgence/outbreak after an extensive pesticide application? Yes [ ] No [ ]

41. Were there any incidents of pesticide poisoning on farm animals, cats, or dogs that happened in your farm? ____

42. Have you ever noticed any incidence of fish kills due to pesticides? ________________

43. What kinds of fish disappeared? ______________________________________

44. Have you ever noticed any incidence of bird kills due to pesticides? ________________

45. How important to you are the following possible risks from the use of pesticides on your farm?

Possible Risks	Very Important	Somewhat Important	Not Important	Relative Rank
Damage to human health from Handling and applying pesticides				
Harmful effects to fish & other Aquatic species				
Harmful effects to birds				
Harmful effects to mammals, farm animals				
Toxicity to beneficial insects				

<u>Adoption of specific IPM technologies being developed for onions and eggplant:</u>

PhilRice researchers are conducting experiments to test various cultural, chemical, and biological control practices that could possibly reduce pesticide applications without affecting yields. These practices are being developed not only to reduce costs but also to protect human health and prevent environmental degradation. We would like to determine your willingness to adopt the following technologies.

46. Do you think you will adopt any of the following practices? Indicate if already being practiced.

		Yes	No
a.	regular removal of damaged eggplant		
b.	spraying of Brodan only every 3 weeks		
c.	rice straw mulching		
d.	1 herbicide application + 1 handweeding (instead of 2 herbicide applications + 2 handweeding)		
e.	rice hull burning		
f.	use of castor as trap plant		
g.	use of pheromone traps		
h.	biological controls (i.e. NPV, Bt, etc)		

<u>Willingness-to-Pay Questions</u>:

47. We would like to ask you questions about pesticide choices you might make next year. Assume that next year you will be planting the same crops and that climatic and pest conditions will be the same as this year.

(a) Suppose that a chemical company made a new formulation of (specify the most familiar/commonly used insecticide based on answer to question no. 16)__________________ that was very similar to this insecticide in all respects (especially efficacy) and the only difference is that this new formulation does not cause human health problems. If this new formulation costs P____ (*offer different prices higher than the cost of stated insecticide in 50-peso increments*) will you buy this new formulation?
(Note: as soon as the respondent says NO, indicate last price agreeable to respondent)

(b) Suppose that a chemical company made a new formulation of (specify the most familiar/commonly used insecticide based on answer to question no. 16)__________________ that was very similar to this insecticide in all respects (especially efficacy) and the only difference is that this new formulation does not kill the natural pest enemies or beneficial insects. If this new formulation costs P____ (*offer different prices higher than the cost of stated insecticide in 50-peso increments*) will you buy this new formulation?
(Note: as soon as the respondent says NO, indicate last price agreeable to respondent)

(c) Suppose that a chemical company made a new formulation of (specify the most familiar/commonly used insecticide based on answer to question no. 16)__________________ that was very similar to this insecticide in all respects (especially efficacy) and the only difference is that this new formulation does not kill or contaminate the fish and other aquatic species in our surface waters. If this new formulation costs P____ (*offer different prices higher than the cost of stated insecticide in 50-peso increments*) will you buy this new formulation?
(Note: as soon as the respondent says NO, indicate last price agreeable to respondent)

(d) Suppose that a chemical company made a new formulation of (specify the most familiar/commonly used insecticide based on answer to question no. 16)__________________ that was very similar to this insecticide in all respects (especially efficacy) and the only difference is that this new formulation does not kill the birds in this area. If this new formulation costs P____ (*offer different prices higher than the cost of stated insecticide in 50-peso increments*) will you buy this new formulation?
(Note: as soon as the respondent says NO, indicate last price agreeable to respondent)

(e) Suppose that a chemical company made a new formulation of (specify the most familiar/commonly used insecticide based on answer to question no. 16)__________________ that was very similar to this insecticide in all respects (especially efficacy) and the only difference is that this new formulation does not kill the animals in the farm including the dogs and cats. If this new formulation costs P____ (*offer different prices higher than the cost of stated insecticide in 50-peso increments*) will you buy this new formulation?
(Note: as soon as the respondent says NO, indicate last price agreeable to respondent)

Related Information

48. Is there any body of water containing fish that is near your farm?

    Yes [ ]   No [ ]

    How near is it (in meters)? ____

49. What kinds of fish are found in this body of water? ___________________________________

50. Do you consume fish from this source? Yes [ ]   No [ ]

51. What kinds of animals do you have here in the farm? _________________________________

52. What are your sources of drinking water? ____

53. Do you boil your drinking water? Yes [ ] No [ ]

54. Do you have a deep well? Yes [ ] No [ ]

How deep is it?___________________________

55. Do you wear protective clothing when you apply pesticides?

	Yes	No
Mask/Substitutes for mask		
Long Pants		
Long Sleeves		
Slippers/Shoes		

56. What is the daily wage of pesticide applicators? _____________________________

57. What is the daily wage paid to workers that do handweeding? ______________

58. What is the daily wage paid to transplanters/harvesters? ______________________

59. Do you pay a higher/lower wage rate for the pesticide applicators? ______________

60. How many children are living near the farm? _________________________________

VITA

LEAH CONCEPCION MARQUEZ CUYNO

Leah Cuyno was born on December 7, 1969 in Pangasinan, Philippines. She grew up in Los Banos, Laguna where her father worked as a professor in the University of the Philippines (UPLB) and her mother worked as a Food and Housing Supervisor in the International Rice Research Institute (IRRI). She received her Bachelor's degree in 1990 in Agricultural Economics from UPLB where she wrote a thesis about the market potentials of non-traditional coconut by-products. After college, she worked as a science research specialist for the Technology Application and Promotion Institute of the Department of Science and Technology. Two years later, she decided to pursue a Master's degree in Agricultural Economics at Michigan State University. Her master's thesis is entitled "Targeting Areas as a Cost-Effective Method of Agricultural Nonpoint Source Pollution Control".

She is looking forward to rejoining her family in the Philippines and doing research on environmental and international development issues.