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:

$$\text{Max}_x \; E[\text{profit}] = (\text{Price} * \text{Yield}) - \text{variable factor costs} - \text{fixed costs}$$

$$\text{subject to:} \quad Y = f(\text{fertilizer inputs, pesticide inputs, other inputs})$$

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.