Assessing Farm-level and Aggregate Economic Impacts of Olive Integrated Pest Management Programs in Albania: An Ex-Ante Analysis

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(ABSTRACT)

Concerns about the harmful effects of pesticides on the environment, human health, and wildlife have led to research and promotion of integrated pest management (IPM) strategies. Recently, an IPM program was introduced in the Albanian olive sector through the USAID-funded global IPM-CRSP project to develop improved olive IPM technologies. This study develops and applies a protocol for integrated economic impact assessment of olive pest management strategies designed by the IPM-CRSP project in Albania. The main components of the integrated approach for economic impact assessment of olive IPM include (i) net return analysis for measuring farm level impacts; (ii) economic surplus modeling for measuring market-level impacts; and (iii) modeling of IPM adoption under output uncertainty. The economic surplus equilibrium displacement model developed for the Albanian olive market with no international trade accounts for IPM research-induced supply shifts, increased demand due to quality improvement, and research-induced spillovers to non-target zones.

The main sources of data for performing partial budgeting and economic surplus analysis were: (i) an expert survey; (ii) partial budgets compiled based on a farmer survey and expenditure records from field-level experiments; and (iii) data collected at the market level. The data used to estimate the dichotomous logit model came from a 1999 survey of 200 growers and a survey of 120 growers carried out in 2000 in the Vlora district of Albania.

The net return analysis indicates that compared to conventional practices, the proposed olive IPM packages generally promise higher yields, improved quality of olive products, lower pesticide use, and higher net returns to producers. However, adoption of some of the IPM practices implied higher production costs. Based on the simulation results, the Albanian olive industry has the potential to derive a net IPM research benefit between $39 million (assuming that farmers move directly from minimum spraying to IPM) and $52 million (assuming that farmers move from full pesticide program to IPM) over the next 30 years. Farmers' reliance on pesticide use on olives and other crops does not seem to hinder IPM adoption. Grower perceptions and the process of expectation formation significantly influence adoption decisions. Addressing the process of expectation formation and changing these perceptions by educational programs and better access to information will encourage IPM adoption.

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Chapter 1: Introduction

1.1 Background

Agricultural pests cause substantial crop losses throughout the world. Historically, farmers had to manage this problem to secure their basic subsistence needs. As a response, farmers have practiced and developed cultural and mechanical pest control based on trial and error. Over time, these practices have become a part of their production management system. Even though the first known chemical control dates back 2,500 years, the chemical age began in the 1940’s with the discovery of DDT (insecticide), ferbam (fungicide), and 2,4-D (herbicide) (Arneson & Losey, 1997).

Pesticides are an important input for increasing food production to meet a growing food demand. In the 1940s and 1950s, pesticides were thought to be the final word in pest control and their introduction contributed substantially to raising agricultural productivity in many regions of the world. Since then, pesticides have become an integral component of many intensive agricultural systems. However, the benefits of pesticide use in agriculture can be offset in some cases by the social cost of pesticide pollution. Rachel Carson’s book *Silent Spring* (Carson, 1962) played a pivotal role in drawing public attention to the harmful effects caused by pesticides to the environment, human health, and wildlife.

Many studies have shown that repeated application of pesticides selects for resistance on the part of the pest (Adams, 1990; Beaumont, 1993). This resistance leads to the increased application of pesticides and to the collapse of the agricultural systems characterized by highly resistant pests, with no natural enemies left to control them. These negative effects become of particular concern when pesticide use increases in response to pest resistance, pest resurgence, and secondary pest outbreaks. Crop losses caused by pests may be substantial and the damage to the ecosystem disastrous.

In most countries with intensive agricultural systems, the use of pesticides has become an area of environmental concern. Pesticide use is accompanied by several externalities that are harmful to the environment and to human health. Pesticides have been found to cause: acute human health effects, chronic human health effects, contamination of groundwater, contamination of surface water, atmospheric contamination, and negative effects on non-target organisms (Howard et al., 1991; Mullen, 1995). This situation is a concern not only for the developed nations. Although developing countries account for a relatively small portion of total pesticide used each year, they have the highest rates of pesticide poisoning of humans (Adams, 1990; Beaumont, 1993). For example, in Albania many agricultural specialists point out that health concerns related to pesticide use have always been present, especially on the ex-state farms (Isufi, 1997).

Concerns about the negative effects of pesticides have led to research and promotion of alternative pest management practices. These management practices are known as Integrated Pest Management or simply IPM. Definitions of IPM have abounded during the last four decades. Mostly they are goal, commodity, and location specific definitions. Bajwa and Kogan (1998) have documented around 70 definitions of IPM for the period 1950-1998 as cited by different authors. This study adopts the definition used by Norton and Mullen (1994) in which IPM is defined as an approach to making pest management decisions with increased information and multiple tactics to manage pest populations in an economically efficient and ecologically sound manner. A pest is defined as any organism that interferes with the crop and adversely affects crop production. “Integrated” means that a broad interdisciplinary approach is applied using scientific principles of plant protection to incorporate a variety of pest management strategies and tactics into a single system. This integration of techniques must be compatible with agricultural and marketing systems (Arneson & Losey, 1997). Management here refers to the decision making process to control pest populations in a planned, systematic way by keeping their numbers or damage at economically acceptable levels. Tactics include chemical, biological, cultural, physical, genetic and regulatory procedures.

IPM constitutes a paradigm shift in crop protection. In fact, since the 1960s, IPM has been the dominant paradigm in pest control (Morse & Buhler, 1997). In the last two decades IPM has grown into a worldwide effort in its research and implementation. Initially, the impetus behind IPM arose from environmental concerns (Morse & Buhler, 1997). However, some note that recent developments related to IPM have been driven by economic factors. “The driving force behind USA research and development in IPM since the 1970s has been profit…Concerns over environmental contamination by input-oriented agriculturalists were not the major concerns of the majority of producers and those who advised them” (Barfield & Swisher, 1994; p. 216). Others emphasize that the balance among social, environmental and economic considerations has been a central theme of IPM since its inception (Cuperus, Berberet, and Kenkel, 1997).

The IPM philosophy does not necessarily imply a complete abolition of pesticide use. It has been argued that well-timed applications of the appropriate doses of carefully selected pesticides can be safe and effective for the control of certain pests (Arneson and Losey, 1997). Therefore, pesticides remain an essential component of IPM strategies.

1.2 General Problem

Since 1991, Albania has been making radical changes in both its political and economic systems. Albania is now in the midst of transition toward a functioning market economy. It has already privatized agriculture, housing, small and medium industries and is working on privatizing large state enterprises. It has liberalized the price formation structures and the exchange systems, consolidated fiscal policies and established monetary and development policies with the help of international financial organizations such as the International Monetary Fund (IMF) and the World Bank. Many institutions are undergoing major changes. However, the transition to a market economy has been slow and difficult. The social unrest that exploded in 1997 after the collapse of pyramid investment schemes swamped the country’s economy and seriously challenged the new market-based institutions. Since then, the country has recovered slowly due to a lack of political stability.

This situation has negatively affected the rate of market reform as well as the performance of various sectors of the Albanian economy. Also, institutional and technical change in the agricultural sector is taking place very slowly. The lagged introduction of market-based agricultural institutions is explained by the existence of diverse interests of different agents involved in this process, as well as other constraints and problems that accompany the transition period. The private farms in Albania suffer from a lack of inputs, institutions, and infrastructure needed to support efficient agricultural operations. Because of the risk farmers face, the lack of well-functioning markets and the absence of cooperative institutions, retrenchment is their dominant attitude (Daku, 1997). Despite these constraints, Albanian farmers are striving to pave the way toward development and progress.

Need for environmentally sound technologies

The adoption of new technologies and practices in farming activities is of crucial importance for Albania, a country with a rapidly increasing population and severe scarcity of productive agricultural lands. Raising agricultural productivity through new technology is also essential to the alleviation of poverty and to assure the country's economic growth. Equally important over the long term is helping farmers adopt more environmentally sound agricultural practices. The gradual expansion of agricultural land through land reclamation and improvement programs since 1946 has been one of the major determinants of the increase of agricultural production in Albania. As the sources for further expansion of agricultural land are exhausted, almost all increases in Albanian agricultural production will have to come from higher output per hectare. Therefore the trend of shifting from resource-based to technology-based farming systems also requires an explicit policy framework for providing new technologies and information to agricultural producers. Indeed, the institutionalization of IPM practices in Albania may contribute towards this transition to a technology-based agriculture.

Pesticide use and IPM programs in Albanian agriculture

IPM is not a new concept in Albanian agriculture. Researchers began conducting field experiments and developing alternative pest control practices for many crops in the 1980s. These practices, which included various elements of IPM, differed substantially from conventional methods and resulted in a reduction of pesticide use (Isufi, 1997). Nevertheless, it should be noted that these “scattered” elements of IPM practices were only a small part of the agricultural research programs and they were not widely extended at the farm level. During the three decades preceding 1990, pest control in the country’s major crops has been heavily based on pesticide use (MOAF, 1990). However, even during peak years of utilization, Albania used fertilizers and pesticides less than almost any other nation in Eastern Europe (Isufi, 1997).

In the early 1990s, the agricultural sector experienced a fertilizer shortage. Supplies of pesticides also ran low. In 1989 Albanian farmers applied about 158 kilograms of active ingredients per hectare, but the country's economic breakdown pushed the total down to 135 kilograms in 1990 and 38 kilograms by 1991. A lack of hard currency caused fertilizer supplies to drop 80 percent and pesticide reserves to fall 63 percent (Isufi, 1997). Ironically, intensive application of lindane and other pesticides as well as disinfectants for treating soil at seeding time, in combination with monocropping of wheat and corn, had destroyed many pests' natural enemies and increased dependency on pesticides.

Albanian agriculture has historically relied upon imports for its supply of pesticides. Statistics on pesticides show that during the 1970s and early 1980s, the level of the pesticide use followed an upward trend. Although, pesticide use has recently dropped drastically due to the weak economic position of farmers and the lack of functioning agricultural input markets, this situation will not last for long. As farmers’ economic situation improves and the agricultural input markets consolidate, farmers’ ability to purchase off-farm inputs, including pesticides, will increase. Therefore, it is necessary that increasing pesticide use be tempered by an integrated approach of pest management that will optimize crop production and maximize net economic returns while minimizing pesticide use and damage to human health and the environment. In this context, introduction of IPM practices constitutes an essential tool for achieving sustainable agricultural development in Albania.

Olive pest control

During the almost five decades of the communist regime, control of olive pests in Albania was largely based on pesticides. Because of the widespread use of pesticides on olive orchards, all of the adverse effects of pesticide use mentioned above have been reported in the country's major olive growing areas over time (Isufi, 1997). The economic changes and structural reforms in Albanian agriculture in the early 1990's substantially affected pest control in olive groves. The process of fruit tree distribution following the decollectivization program in 1991 was in many cases spontaneous and not well organized. As a result, farmers received olive trees scattered in several locations. Having olive trees scattered in 3 to 6 plots hinders the application of agricultural practices especially those related to pest management. It also increases the cost of production by involving extra expenditure for chemical treatment, transportation, labor, and so forth.

Losses caused by olive pests in the Mediterranean region, including Albania, are roughly estimated to be from 10 to 50 percent of marketable production, including table olives and oil olives (Katsoyannos, 1992)[1]. Olive production losses due to pests vary greatly in terms of olive cultivars and their susceptibility to pests, soil fertility, climatic conditions, olive's biennial cropping pattern, regions and so forth. Infestation by the olive fruit fly, *Bactrocera* (*Dacus) oleae (Gumelin),* is a major cause of high acidity[2] in olives, which lowers the quality of the product. Promptness in processing after harvest is very important since the fruit continues to degrade with time. Some olive cultivars in Albania have oil content up to 30%. While the fruits are still on the trees, the level of acidity is less than 1% but after harvest it can rise.

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[1] This subsection refers mainly to Katsoyannos (1992), unless otherwise stated.

[2] The level of acidity determines the rating of the oil: extra virgin has less than 1% oleic acid, virgin has 1-3% oleic acid, and virgin lampante has greater than 3%.

Olive production in Albania uses very little pesticides, fertilizers and other inputs. Only a few farmers in the olive growing areas are reported to have used pesticides since 1993, when they took over the state-owned olive trees (IPM-CRSP, 1998). As a result, the production losses are substantial, table olives are of low quality and olive oil has high acidity.

Olive growers do not use pesticides for reasons other than access to input markets and health and environmental concerns. First, farmers do not have the economic resources to purchase inputs. Equally important is the fact that presently farmers have limited knowledge regarding olive pests and their control. Agricultural research and extension that could provide such knowledge have poor links with farmers[3]. From a participatory appraisal (PA) of olive growers in the southern part of Albania in July 1998, it was found that farmers know about fertilization and other management practices of olives, but not much about methods for controlling olive pests and less so about IPM practices (Luther et al., 1999). The PA also found that only a few farmers were spraying olives. However, the baseline survey conducted one year later indicated that the number of farmers applying pesticides on olives had increased as compared to the previous year (Daku et al, 2000).

IPM CRSP/Albania Project

The Integrated Pest Management Collaborative Research Support Program in Albania (IPM CRSP/Albania) funded by United States Agency for International Development (USAID) is currently collaborating with Albanian research institutions to develop improved olive IPM technologies. The IPM CRSP/Albania project is an integral part of the Global IPM Project. The IPM CRSP is composed of a consortium of U.S., host country, and international research institutions with the Management Entity (ME) based in the Office of International Research and Development (OIRD) at Virginia Tech. The latter is charged with managing IPM CRSP and a USAID Project Manager monitors its progress. The IPM CRSP/Albania project is financed by the USAID Mission in Tirana with a grant for a three-year period. The major Albanian institutions

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[3] For more information on this matter see (Daku et al., 2000).

involved are the Plant Protection Research Institute (PPRI) in Durres, the Fruit Tree Research Institute (FTRI) in Vlore, and the Agricultural University of Tirana (AUT).

The efforts to initiate this project started in 1996. In September 1996 and February 1998, two teams of IPM CRSP scientists went to Albania for data-gathering missions to prepare the project proposal in close collaboration with the above mentioned Albanian institutions and the USAID Office in Tirana. During the stakeholders' meeting in February 1998, olive was chosen as a priority crop for the IPM CRSP project. The USAID/Albania Mission approved funds for the project in May 1998.

The first activity of the IPM CRSP/Albania Project, the participatory appraisal (PA) of olive growers' pest control practices, was implemented in the southern part of Albania (Vlore-Fier-Berat) in July-August 1998. Specialists from the three Albanian institutions (FTRI, PPRI, AUT) as well as from American universities (Virginia Tech, Pennsylvania State University, University of California Davis, and University of California Riverside) participated in this PA activity. During this activity, the research group conducted relatively unstructured but in-depth interviews with olive growers. A structured baseline survey was then conducted to verify the results of the PA with a larger sample of farms and a more quantitative analysis. Researchers have used this information to design field experiments and are now conducting the experiments.

Need for integrated impact assessment of olive IPM

The integrated impact assessment in general terms refers to the economic analysis of the full range of the consequences, immediate and long term, intended and unanticipated, of the introduction of a new technology, project, or research program (Porter and Rossini, 1983). The adoption by farmers of olive IPM practices developed and tested by IPM CRSP/Albania projects may have several potential benefits. These practices will lead to the use of pesticides on an as needed basis only. Because of this method, many undesirable effects associated with pesticide use may either be reduced or eliminated. These effects would include resistance development in pests to pesticides, pests resurgence and secondary pest outbreaks, excessive pesticide residue in table olives and olive oil, inadequate cosmetics of marketable olive fruit, cases of poisonings (human, domestic animals and wildlife), adverse impacts on non-target organisms, and environmental pollution. There also could be relatively lower national expenditures on pesticide subsidies (if any) and purchases than without an IPM approach[4]. Additionally, lower imports of pesticides leads to savings in foreign exchange.

The implementation of IPM strategies is expected to lead to an increase in olive yields and farm profitability and to lower variability of yields and income. In addition, other positive impacts of IPM would include a reduction in government subsidy for pesticides and olive tree sprayings, if any. However, it is likely that the latter benefits may be offset by cost of providing information on IPM practices incurred by government as well as public funds for IPM promotion such as subsidies for scouting services in olive growing regions. However, farmers need to not only be informed about the existence of IPM as an environmentally sound strategy for olive pest control, but they also should be provided with estimates of the potential farm-level profitability of IPM strategies to foster IPM adoption.

Recently, there have been growing interests by researchers in studying the effects of IPM on fruit and vegetable production mainly for two reasons: first, fruit and vegetable production is particularly intensive in pesticide use and second, pesticide residues on fruit and vegetable products are more likely to cause human poisoning because they are often consumed with little postharvest processing (Fernandez-Cornejo, 1999). Indeed, the latter is of serious concern in developing countries including Albania. Among fruits, most IPM research has been carried out on apples (Norton and Mullen, 1994), a few studies on oranges (Fernandez-Cornejo and Jans, 1996), and on grapes and peaches (Fernandez-Cornejo, 1998; Fernandez-Cornejo and Ferraioli 1999). However, no studies on the impact of IPM on olive production have been published.

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[4] Currently, there are no pesticide subsidies in Albania

The assessment and quantification of all of the potential impacts of the olive IPM program, which could be roughly grouped into three main categories: biological, environmental, and economic, would be an enormous task. Therefore, this study will concentrate on evaluation of economic impacts of IPM CRSP research on olives.

1.3 Specific Problem

The problem faced by olive growers in the study area is that of finding an approach to controlling olive pests in order to: raise production and improve its quality, enhance income and standards of living, and minimize pesticide use and its adverse effects on the environment and human health. Introduction of IPM practices into the olive production system may facilitate the achievement of these goals. The institutionalization of IPM within the country's national strategy for crop protection raises several questions: (i) Do the tested olive IPM practices increase income and lower the costs and variability of yields compared to conventional methods of pest control? (ii) Do the IPM strategies provide enough economic benefits to the society as to be institutionalized as a national strategy for crop protection? (iii) What are the major factors and barriers that affect the prospects of farmer adoption of IPM practices and what kind of knowledge base and information system do we need to support the implementation of IPM practices?

As with any new technology, introduction of olive IPM practices raises the question as to whether these practices are economically viable for farmers in the study area. Economic benefits and costs associated with IPM programs should be evaluated along with their testing under local conditions to make sure that farmers will have strong incentives to adopt them. Several studies have been carried out to identify the net economic benefits incurred by farmers who adopt IPM practices. In their literature review of economic evaluation of IPM programs, Norton and Mullen (1994) conclude that in the United States, net returns and yields at the farm level are generally higher and production costs and risk are lower when IPM is adopted. Also, most studies show that pesticide use is lower after IPM adoption (Norton & Mullen, 1994). All of these effects generate economic benefits at the farm level and aggregate benefits for the society at large.

The economic evaluation of olive IPM programs at the farm level should begin with the assessment of the potential private benefits and costs to the producers (olive growers). As is the case with any technology innovations, farmers will adopt IPM practices only if they have enough incentives to do so, that is if the economic benefits exceed the associated costs. Therefore, the likely effects of olive IPM practices on net returns at the farm level must be assessed. The results obtained from any favorable evaluations can serve as a primary source of information to inform farmers about the advantages of IPM strategies. Evaluation of production costs and potential profits may be instrumental in convincing growers to adopt new IPM technologies.

This study is important to Albania because production and income losses caused by various pests are presently high on all agricultural crops, including olives. Furthermore, a comprehensive study on the economic evaluation of IPM practices in Albania has never been conducted. The system for IPM impact assessment developed in this study will serve as a model to extend the impact analysis to other crops. Implications derived will help policy-makers better understand that policy-making needs to be based on findings of empirical research.

Policy makers and research directors need to know the magnitude of the net benefits of IPM to producers and consumers or to society at large in order for them to gain insight into the merits of supporting IPM strategies. Information on the social benefits of IPM practices could provide a basis for policy makers to design and formulate comprehensive agricultural policy programs that incorporate IPM practices into a national strategy of pest control. The assessment of IPM impacts could help the process of planning and priority setting in agricultural research.

Small-scale farmers’ perception about pests, pesticides, and pest control as well as their decision making process in pest management have been shown to be influenced by a range of political, social, economic, cultural and institutional factors (Feder et al, 1985; Napit, 1988; Harper et al, 1990)[5]. Basically, almost all technology adoption studies are conducted *ex-post*, that is, after the research has been carried out. Yet it is equally important to examine the role of farmers' perceived risk of IPM and other informational factors on the likely rate of adoption prior to introduction of technology. An *ex-ante* model of IPM adoption would help gain insights into the major determinants of farmers' decision about whether to adopt IPM practices. The findings from this model would allow design of better public policies for influencing farmers' perception of IPM and improve information dissemination among farmers.

Farmers' acceptance of IPM practices depends on many factors that are internal and external to the farmers themselves. Factors that may influence the likely rate of IPM adoption are related to farm characteristics and the outside influences composed of social, economic, political, and institutional factors. Socio-economic, cultural and behavioral characteristics of farmers are also expected to play a significant role in farmer decisions relating to IPM adoption. The development of an IPM adoption model seeks to establish the links between the adoption of IPM practices and strategies in olive production and the socio-economic and institutional environment affecting the farm as well as the socio-economic and behavioral characteristics of farmers themselves. Understanding these linkages and identifying the major socio-economic and institutional factors as well as knowledge gaps associated with different pest management practices may help formulate policies that stimulate the process of adoption and diffusion of those practices.

1.4 Objectives and Hypotheses

This study focuses on the ex-ante analysis of potential economic impacts resulting from pest management strategies on olives developed and tested by the IPM-CRSP/Albania project in Vlora district, Albania. It also seeks to examine the prospects for getting olive growers in the region to accept a new integrated pest management (IPM) production system for olive production.

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[5] For a comprehensive survey of literature on this topic see (Feder et al., 1985).

The overall objective of this study is to design a system for integrated assessment of the potential farm-level and country-wide economic impacts of olive IPM CRSP practices and to apply this system to the olive growing region of Vlora, in southern Albania. A protocol could then be developed for use in future IPM impact assessments in Albania or elsewhere. Application of the system to Albania's olive IPM program involves the following specific objectives:

1. Assessment of the potential impacts of olive IPM practices on the level of net returns to farmers.
2. Estimation of the potential aggregate economic impacts of olive IPM programs for producers, consumers, and the country as a whole.
3. Examination of the effects of farmers' perceived risk of IPM and other economic, social, and informational factors on the prospects for adoption of IPM practices by olive growers.

Throughout this study, it will be assumed that the main objective of olive growers in their production and marketing decisions regarding the olive production system is profit maximization[6]. An additional assumption is that farmers have a secondary objective of risk minimization since this study also seeks to test for the effects of farmers' perception of IPM riskiness on likely rate of IPM adoption. Based on the specific objectives, this study seeks to test the following hypotheses:

1. Olive IPM practices will result in higher income for farms that adopt IPM.
2. Tested olive IPM practices generate countrywide net economic benefits.

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[6] This assumption is strongly supported by the data from a baseline survey conducted in the study area in 1999. According to that survey, olives are a cash crop in the study area. Specifically, with regard to olive sales, it was found that: (i) forty-five percent of the farmers interviewed reported olives as the most important source of income, (ii) the majority of farmers (60%) marketed part of their olive oil production, and (iii) the largest portion of the olive oil produced (58.3%) was sold in the market and the remainder (41.7%) was used for family consumption (Daku et al., 2000).

3. The expected rate of IPM adoption is positively related to the number of olive trees per farm, education level of farm operators, yield, IPM awareness and frequency of contacts with extension and research specialists.
4. Adoption of IPM is negatively related to farmers' perceived risk of IPM, farming experience, percentage of olive oil production sold, ranking of olives as a major source of income, ownership of sprayer, pesticide application on grapes and frequency of contacts with pesticide dealers.

1.5 Summary of Methods

The economic feasibility of olive IPM practices at the farm level is an essential element for IPM implementation. The potential farm level impacts are assessed using enterprise and partial budgeting analysis. Olive crop budgets are developed including input quantities and costs and output quantities and prices, so that net returns can be calculated for current conventional pest control practices and these can be compared with estimates of net returns under IPM production practices as elicited from a survey of experts in olive production. Variable costs are broken down into pest management and non-pest management costs. Next, the crop budgets are used to compare yields, costs and profitability of alternative olive IPM practices. The results obtained from the assessment of potential farm-level impacts of olive IPM practices are preliminary because the field experiments are underway. However, crop budgets for the olive production system under IPM are estimated based on the preliminary results of the field experiments as well as the opinions elicited from researchers involved in IPM CRSP field research.

Economic surplus analysis is used for the second objective to estimate the potential aggregate economic impacts of olive IPM programs to producers and consumers and to society at large. The economic surplus model and procedures developed by Alston, Norton, and Pardey (1995) are applied to estimate the potential aggregate impacts of IPM CRSP practices.

To achieve the third objective, a limited-dependent variable approach is applied to estimate the adoption model (logit model). The logit model specification is based on two different sets of data and dependent variables. The first model specification is estimated using as a “proxy” dependent variable the adoption of innovative non-chemical olive pest management practices based on 1999 survey data. The second model specification is estimated using as dependent variable farmers’ willingness to adopt IPM practices once they are released based on 2000 survey data. Given the fact that area-wide pest control is needed, an area-wide adoption is essential for IPM to be effective. For this purpose, the question on whether farmers plan to adopt IPM practices is related to two to three key pests as identified by baseline survey data. Additional information is collected with respect to (i) social, economic, institutional, and demographic factors (ii) policy and political factors in connection with IPM, (3) the role of institutions, and (4) IPM support activities and pest management research capacity.

Two farm-level surveys and an expert survey were conducted to collect data needed for this study. The expert survey elicited researchers’ assessments on the likely effects of IPM research on olive supply and demand, costs, income, probability of research success, adoption, and other components related to the procedures for estimating the aggregate benefits of IPM research. The Stanford/SRI protocol for eliciting expert’s opinions was applied during the expert interviews.[7] Additionally, data on olive production, prices of olive products, population growth, and pesticide use were collected from secondary sources.

A farm-level baseline survey and a follow-up survey were conducted with olive growers in the study area. In these surveys, information on current pest management practices, pest status, farmers and agricultural specialists and experts’ perceptions about pests, socio-economic characteristics, role of women in pest management decision-making, influence of government policy on production practices, and so forth was collected.

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[7] For more details on these procedures see chapter 4.

The main purpose of the baseline survey was to identify the farmers' stock of knowledge and farmer perceptions regarding olive pests, natural enemies, and pest management practices, as well as to specify knowledge gaps with respect to olive pest control. Baseline data are required to understand the socio-economic factors that influence pest perceptions, pest management practices and potential constraints to IPM adoption. Data obtained from the baseline survey were used to estimate adoption model as well. The follow-up survey was designed specifically to serve the data requirements of adoption model.

1.6 Organization of Dissertation

The dissertation is organized into six chapters, including the introductory chapter. Chapter 2 provides a review of literature on theory and methods for economic impact assessment of IPM programs at the farm and aggregate levels. Chapter 3 develops the methodology employed in the study for the integrated assessment of olive IPM based on the relevant theory of production and welfare economics. Chapter 4 details the procedures and empirical components with respect to partial budgeting, economic surplus equilibrium displacement model, and IPM adoption model. Chapter 5 presents the results of the model, and the final chapter presents conclusions, policy implications of the results and provides recommendations for future research.

Chapter 2. Literature Review

2.1 Introduction

The objective of this chapter is to critically review previous research carried out on economic impact assessment of IPM programs at the farm and aggregate levels. The chapter is divided into five sections including the introduction. Section 2.2 reviews the major models describing farmers' decision-making processes in pest management including: the economic threshold model, the economic optimization model, the decision theory model, the behavioral decision model, and the participatory model. Section 2.3 summarizes the main findings from studies of the environmental, health and economic costs of pesticide use as well as the net benefits of IPM programs. An extensive discussion of the primary techniques used for evaluating farm level and aggregate economic impacts of IPM programs is presented in section 2.4. Finally, section 2.5 briefly discusses the more common approaches to evaluating of IPM adoption, summarizes stylized facts and research findings on barriers to IPM adoption, and discusses measurement issues related to the level of IPM adoption.

2.2 Decision Making Process in Pest Management

Following widespread concerns about the adverse effects of pesticide use including pesticide resistance, pest resurgence, secondary pest outbreaks, effects on non-target organisms (natural enemies), and pesticide pollution since the early 60's, it became clear that spraying by calendar was not the appropriate approach to pest control. The fundamental questions addressed were: how many insects cause how much damage, and are the damage levels all significant? Experts from a number of agricultural disciplines came to realize that a decision rule or threshold should answer such questions and that pest control ought to be viewed as a decision making process rather than as a list of individual practices for several reasons.

First, decision-making in pest management, like other economic problems in agriculture, involves allocating scarce resources to meet food demand of a growing population. In this process, agricultural producers have to make choices regarding the use of several inputs including labor, insecticides, herbicides, fungicides, and consulting expenses related to the level and intensity of pest infestation and the timing of treatment. Second, pest management at the farm level is not only related to the choice of pest control practices, but also to the optimal level of pest control by a particular practice or set of practices (Norton & Mullen, 1994).

Third, the decision making process for pest control takes place at many levels on the farm and beyond including farmers, managers, sprayers, pest control advisors, researchers, government representatives involved in regulation of pesticide use, chemical industry personnel, pesticide dealers, and so forth. These various layers of decision making affect in one way or another the whole strategy of pest control on a given crop, region or country as well as the set of approaches and methods that are chosen to implement pest control programs.

Fourth, the complexity of interaction between pest populations and the wider environment for a given crop and region necessitates the adoption of a systems approach to managing crop pests. Research has shown that depending upon the pest complex and agro-climatic conditions, pest control programs may differ dramatically for the same crop in different regions and microzones (Mengech et al., 1995). Recognizing this complexity, Pedigo (1996) noted that bioeconomics, the study of the relationships between pest numbers, host responses to injury, and resultant economic losses, is the basis of assessment and decision-making in pest management.

While biological scientists have a primary role in doing research on adverse effects of pesticide use on the agro-ecosystem, there is also a growing role for agricultural economists to be involved in pest management research and decision making. As Davidson and Norgaard put it (1973, p. 2) the economists’ contribution in the design and development of integrated pest management strategies as well as their implications to the farmer, the agricultural sector, and society stems from the fact that: (i) the goals of pest management are largely economic; (ii) as a science of resource allocation, economics can help identify optimal quantities and combinations of pest management inputs; and (iii) economists' growing preoccupation with an institutional view of economic phenomena and processes can lead to a better understanding of the incentive structure underlying farmers' behavior and the effects on these incentives of alternative institutional arrangements for speeding up adoption of integrated pest management practices.

In reviewing the major contributions on the subject, the following models are discussed and cited extensively in the literature as being the most prominent models related to the economics of decision making in pest management (Headley, 1972; Stern, 1973; Mumford and Norton, 1984; Norton and Mumford, 1993; Pedigo and Higley, 1997; Roling and van de Fliert, 1994; Norton et al., 1999): (i) the economic threshold model, (ii) the economic optimization model, (iii) the decision theory model, (iv) the behavioral decision model, and (v) the participatory model.

2.2.1 The Economic Threshold Model

Development of the economic threshold concept and its refinements is a major contribution of entomologists. In the 1960's, researchers came up with the idea of tolerating some level of pest damage, reasoning that most biological species are not pests and most pest species do not cause significant harm at all times and in all locations (Pedigo & Higley, 1997). This conceptual breakthrough implied that limiting pesticide use could lead to conserving natural enemies. Hence, the concepts of economic damage, economic injury level and economic thresholds were developed. Economic damage, economic threshold and economic injury level constitute three basic elements of the economic threshold model (Pedigo, 1999).

Economic Damage (ED) is defined by Stern et al. (1959) as "the amount of injury which will justify the cost of artificial control measures". Based on Stern et al.'s description, Southwood and Norton (1973) presented the following mathematical expression for the economic damage:

$$C(a) = Y[s(a)] * P[s(a)] - Y(s) * P(s) \quad (2.1)$$

Where: Y = yield, P = price per unit of yield, s = level of pest injury, a = control action [s(a) is level of injury as modified by the control action], C = cost of the control action. Equation 2.1 states that cost of the control tactic equals yield times price when the tactic is applied minus yield times price without the tactic. Consequently, economic damage begins when the benefits of suppression exceed costs of control, that is, when $C(a) \leq Y[s(a)] \times P[s(a)] - Y(s) \times P(s)$.

Economic Injury Level (EIL) was defined by Stern et al. (1959) as the lowest population density that will cause economic damage. The EIL is the most essential of the decision rules. However, it is a theoretical value that if attained by a pest population, will result in economic damage (Pedigo, 1999). Mathematically, the EIL is expressed by Pedigo et al. (1986) as:

$$EIL = C/VIDK \quad (2.2)$$

Where: EIL = expressed as pest numbers or injury equivalents, C = cost of management activity per unit of production (e.g. $/ha), V = market value per production unit (e.g. $/kg), I = injury units (damage) per insect per production unit (e.g. proportion defoliated/(insect/ha), D = damage per unit injury (e.g. (kg reduction/ha)/proportion defoliated), K = the proportional reduction of the insect population).

Economic Thresholds (ET). Several alternative definitions of the economic thresholds have been developed since 1959 when this term was first introduced by Stern et al. (1959). Intuitively, the concept of economic threshold implies that if the pest population and the resulting damage are low enough, it does not pay to take control measures. In practice, the term "economic threshold" has been used: (i) to denote the pest population level at which economic loss (i.e. pest damage) begins to occur, and (ii) to indicate the pest population level at which pest control should be initiated given the cost of control (Davidson and Norgaard, 1973).

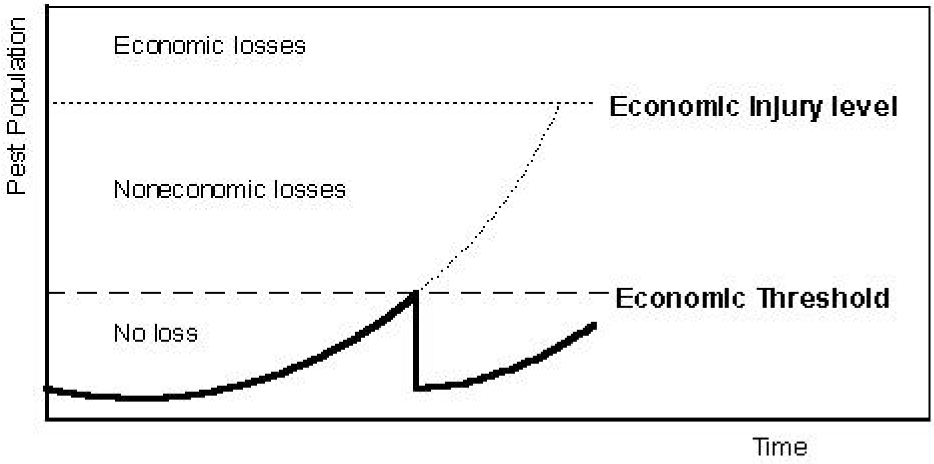

Figure 2.1 Relationship of the Economic Threshold to the Economic Injury Level and Time of Taking Action. (adopted by Stern, 1973)

Stern (1973) defined the economic threshold as the pest density at which control measures should be used to prevent an increasing pest population from reaching economic injury level. The relationship of the ET to the EIL and action times is shown in Figure 2.1. Another definition given by Glass (1975) defines economic threshold as the density of a pest population below which the cost of applying control measures exceeds the losses caused by the pests (figure 2.2).

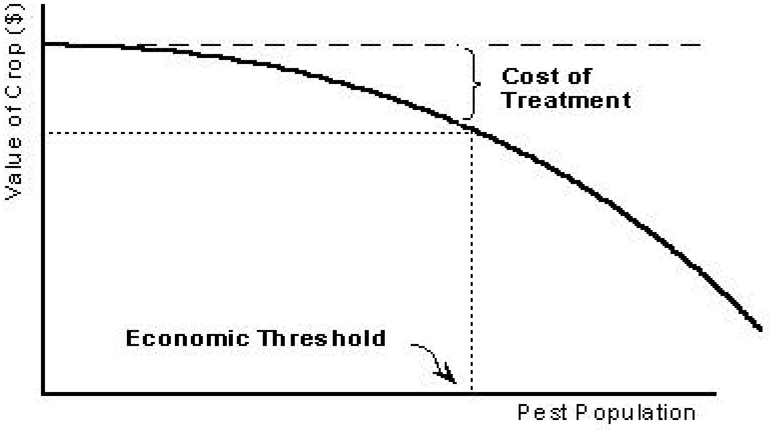

Figure 2.2 Economic Threshold, Value of Crop and Cost of Treatment (adopted by Glass, 1975)

Compared to the EIL, the ET is a practical rule rather than a theoretical one. Economic thresholds are developed taking into account three main factors:

the physical damage caused by pests at a given level of infestation, the revenue losses resulting from that damage, and the costs of treatment. Mumford & Norton (1984) presented the following measure for the ET:

$$PDK\theta = C \qquad (2.3)$$

Where P = price per unit of yield, D = the loss in crop yield per insect per production unit, K = reduction in pest attack, or proportionate reduction in pest attack associated with a particular control action, θ = the level of pest attack C = the cost of control.

The right hand side of (2.3) represents the cost of control and the left hand side represents benefit of control. From (2.3) the economic threshold is derived as:

$$\theta^{*} = C / PDK \qquad (2.4)$$

At this "break-even" point, the benefit of a particular control action (as defined by 2.3) just equals the cost of this control action (C). The expression (2.4) holds for cases when pest problems have linear damage relationship (Fig. 2.3a). In situations where a threshold relationship occurs, Norton and Mumford (1993) redefined expression for economic threshold as (Fig. 2.3b).:

$$\theta^{*} = T + [C \;/\; PDK] \qquad (2.5)$$

where T is the maximum level of pest attack below which losses do not occur

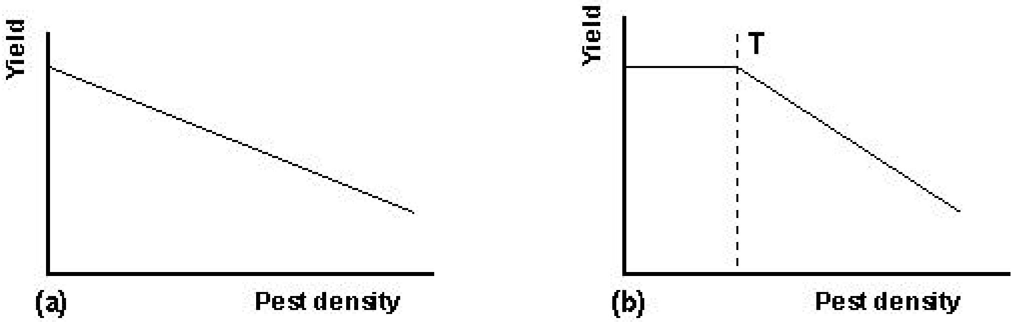

Figure 2.3 Linear and Threshold Damage Realtionship (Norton & Mumford, 1993)

The economic threshold as defined by Stern et al. (1959) has become an operable decision tool. Presently, the use of thresholds is widespread in pest management. Empirically determined economic thresholds, or in other words "action thresholds", have proven very useful in reducing the number of pesticide sprays that are necessary for controlling various pests (Arneson & Losey, 1997). In a monograph published recently on IPM in Albania, Isufi (1997, p. 160) lists action thresholds used for controlling pest in several crops including olives. Suffice it to say, the author provides no information on the methods used to determine those action thresholds.

Several authors have recognized the limitations of the economic threshold model (Poston et al., 1983; Stefanou, 1984; Pedigo, 1999). The ET and EIL concepts have been criticized (i) for being simple and overlooking the influence of other factors within and outside the crop/pest system[8], (ii) for not incorporating important features such as interseasonal dynamics, interactions with other pests and natural enemies, pesticide resistance, and environmental costs in the typical economic threshold decisions, (iii) for yielding relatively inappropriate results in cases of pest management decisions involving multiple pest attacks and multiple treatments. According to Mumford & Norton (1984), it is this last limitation of the economic threshold model that have lead certain agricultural economists to look for alternative decision models in pest management.

2.2.2 The Economic Optimization Model

Entomologists and economists approach the decision making process in pest management by focusing on very different aspects of the problem. As described above, the question posed by entomologists is at what point (pest population level) a particular control action must be taken to prevent a pest population from rising past the point where the damage it would cause exceeds the cost of the control measure. Unlike entomologists, often economists take the pest population as given and seek to answer the question "what level of control is most profitable for that particular pest density" by employing optimality

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[8] Major shortcoming of economic threshold approach is that it is based on very simple population dynamics and control tools.

conditions and specifically the law of diminishing returns. The model assumes perfect knowledge and profit maximization in determining optimal solutions.

Hillebrandt (1960) was the first to employ the concept of marginality in pest control. Using a hypothetical example, she described a dosage response curve in which the crop yield attributable to pesticide application is related to various doses of pesticides and shows how successive pesticide treatment will lead to diminishing returns. Hillebrandt goes on to show there will be an optimal level of pesticide application in terms of profit maximization, beyond which additional treatment gives a reduced increment in returns.

Following the same theoretical grounds, Headley (1972) established a link between economic optimization and earlier work of entomologists on economic thresholds. Headley defined the economic threshold as "the pest population that produces incremental damage equal to the cost of preventing that damage" (p. 105). The concept of economic thresholds as defined by Headley considers three key components: value of production, control costs and pest population.

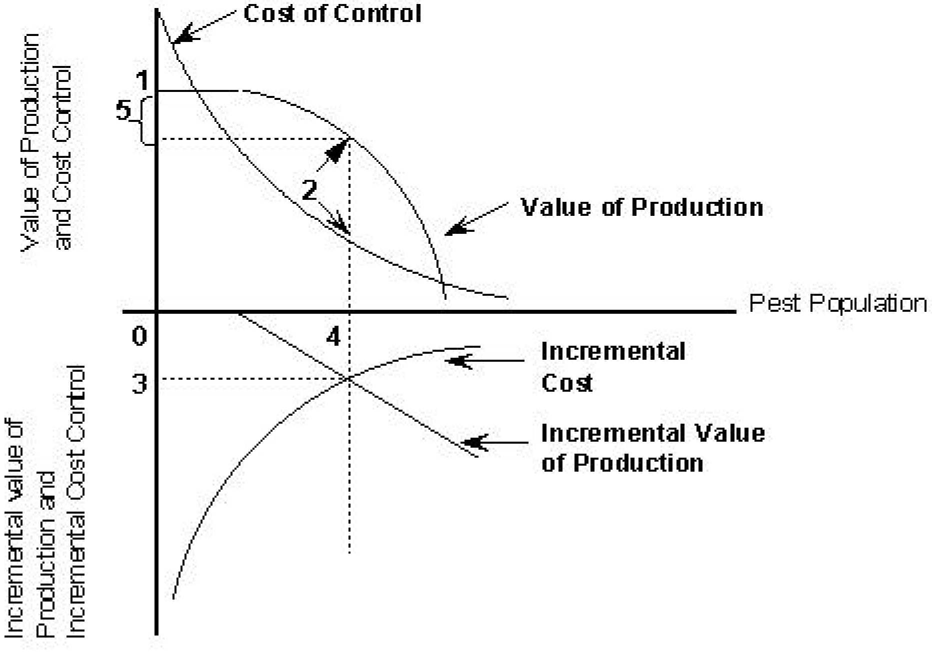


Figure 2.4 Relation of Value of Production, Control Cost, and Pest Population (Headley, 1972)

Referring to Figure 2.4, point 1 represents producer revenue in the absence of pest attack. Point 2 shows the tangency points where the rate of change of the value of production is equal to the rate of change of the cost of control (marginal revenue equals marginal cost). The value of this rate of change is shown at point 3 in the incremental scale.

Given the definition of economic threshold as a break-even point where the cost of control is equal to the benefits of control, then, point 4 is the economic threshold (pest population associated with point 2). Thus, unlike the definition of economic thresholds provided by entomologists, the economic threshold as defined by Headley (1972) represents the optimal (net return-maximizing) level of pest population. No other pest control level provides greater net returns above control costs.

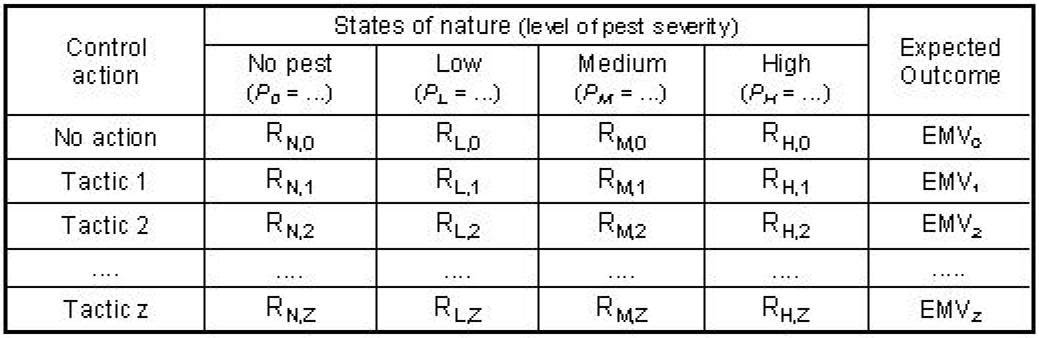
Several authors have attempted to deal with dynamic and spatial aspects involved in pest control. Southwood and Norton (1973), Kogan (1976), and Walker (1977) used real data to illustrate the forms that damage and control cost functions can have in practice. Hall & Norgaard (1973) made further improvements to Headley's theoretical model using simple functions for pest population growth, pest damage, pest control, control costs, and time of application of pesticide treatment. Shoemaker (1979) and Conway et al. (1975) employed a more realistic approach that takes into account the population dynamics of pests. They used dynamic programming to derive optimal solutions for the number and timing of control treatments.

2.2.3 The Decision Theory Model

Mumford and Norton (1993) proposed the application of decision theory to pest control recommendations as a means of countering some of the difficulties of using economic thresholds. These and other authors have stressed the need for thresholds to include the farmers' perceptions of crop/pest loss and a better understanding of how farmers make decisions.

Unlike the two previous models that assume perfect knowledge, the decision theory model considers uncertainty in decision-making process of pest management. Risk and uncertainty in pest management arise due to biological, technical, and economic factors as well as farmers' imperfect knowledge about these factors in a given season.

A better description of this model is provided through pay-off matrices. The pay-off matrix lists projected net returns for different pest management practices and severity of pests. Referring to the pay-off matrix in Figure 2.5, each row shows the damage relationship, that is, the amount of damage associated with different levels of pest attack. In the remaining rows, which involve control action (tactics), each cell (outcome) also includes the cost of control action and its effectiveness in reducing pest attack and damage.



Control action	States of nature (level of pest severity)				Expected Outcome
	No pest (P_0 = ...)	Low (P_L = ...)	Medium (P_M = ...)	High (P_H = ...)	
No action	$R_{N,0}$	$R_{L,0}$	$R_{M,0}$	$R_{H,0}$	EMV_0
Tactic 1	$R_{N,1}$	$R_{L,1}$	$R_{M,1}$	$R_{H,1}$	EMV_1
Tactic 2	$R_{N,2}$	$R_{L,2}$	$R_{M,2}$	$R_{H,2}$	EMV_2
....	....	....	....	....	.....
Tactic z	$R_{N,Z}$	$R_{L,Z}$	$R_{M,Z}$	$R_{H,Z}$	EMV_Z

Figure 2.5 A general Monteray Pay-off Matrix for Pest Control

The expected outcome for each action is calculated as a probability-weighted average outcome. For example, expected monetary value when no action is taken for controlling pests (first row in Figure 2.5) is:

$$EMV_0 = P_0R_{N,0} * P_LR_{L,0} * P_MR_{M,0} * P_HR_{H,0} \qquad (2.6)$$

where EMV – expected monetary value, P – probability of occurrence of the state of nature, and R – projected profit or loss for different control action and pest severity.

Assigning probabilities to each state of nature (level of pest severity) is very important to the outcome of the analysis. Related to this, two approaches have been used to calculate probabilities: one based on objective estimates and the other on subjective estimates (Bosch, 1997). Objective probabilities are based on historical information and reflect the past frequency of occurrence of the states of nature. Subjective probabilities are elicited from expert judgment. Also, the outcome cells in the matrix could be subdivided to account for risk associated with crop prices and other factors (Norton and Mullen, 1994). Choosing the best expected outcome depends on the degree of farmers' risk aversion. Those producers, who are unconcerned with variations in outcomes, that is, risk neutral producers, will choose the option with the highest expected monetary value. However, farmers are often risk averse and being so they are willing to trade off some monetary gains for reduced risk of loss.

Carlson (1970) conducted an economic analysis using a decision theory framework for pest control decision making. He elicited subjective probabilities of a range of losses from peach brown rot, the cost of control, and value of the crop by interviewing peach growers. Information on the effectiveness of five possible treatments for the disease was obtained from field trials. Based on this information, Carlson derived net returns and the expected outcome for each pest treatment and presented the results in a pay-off matrix.

Another model that accounts for the degree of uncertainty in pest management decisions is that provided by Feder (1979). Feder expanded the economic optimization model with fixed damage and a control functions by introducing random elements for pest level, damage per pest, and effectiveness of the control measure. The farmers' risk attitudes also were considered to investigate the impact of uncertainty on farmers' decisions regarding pesticide use and the way the attitudes toward risk affects their reaction to various changes. The major policy implication of Feder's model is that even though pesticide use might reduce uncertainty, information regarding old and new technologies could be a substitute for pesticides, depending on relative costs and availability.

2.2.4 The Behavioral Decision Model

This model is based on the belief that farmers' pest management decisions often reflect their individual perception of the pest problems and not the actual situation. Tai (1977) found that pesticide use per hectare varied much more between farmers than between crops on the same farm, even though pest problems were different. Daku et al. (2000) found a similar relationship from a baseline survey conducted with olive growers in Albania. The survey showed that farmers applying pesticides on grapes were more likely to use pesticides on olives than those farmers who had not sprayed grapes at all.

By developing the behavioral decision model, Norton and Mumford (1983) seek to account for these variations in pesticide use among farmers and try to incorporate their behavior into the pest control decision-making. The model is composed of static and dynamic components.

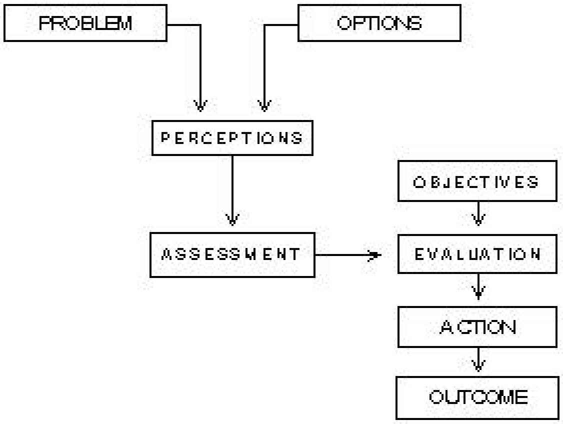


Figure 2.6 The Static Decision Model (Norton & Mumford, 1983)

The static model (Figure 2.6) involves the following elements: (i) the actual pest problem and real options for tackling that problem, (ii) farmer’s perceptions of the pest problem, (iii) farmer’s assessment of expected outcome based on the individual perception of the pest problem and options available, (iv) farmer’s evaluation of expected outcome as related to his own personal objectives, (v) action chosen by farmer following the evaluation. Farmers’ perceptions of the pest problem, which may not necessarily reflect the real situation, constitute the key element to the whole decision making process.

The dynamic decision model (Figure 2.7) accounts for temporal aspects of pest management decisions as well as for the influence of other farm managerial decisions made by the farmer. As Figure 2.7 shows a decision that will be made in a particular season *(t+1)* can be influenced by the decision in previous season *(t)*, farmer's experience, and other pest management decision problems.

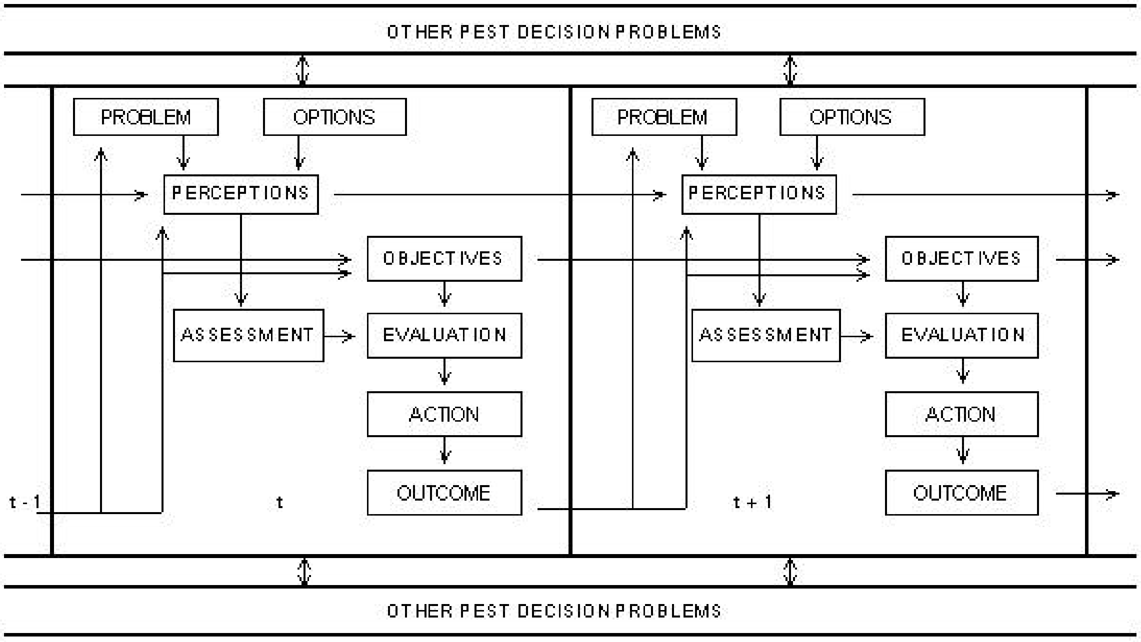


Figure 2.7 The Dynamic Decision Model (Norton & Mumford, 1983)

The major implication coming from this model is that behavioral characteristics of farmers' decision making concerning pest control need to be recognized and evaluated if appropriate pest management strategies are to be developed and implemented.

2.2.4 The Participatory Model

Since the mid 1980's, the emphasis on participatory approaches to IPM has intensified (Roling and van de Fliert, 1994; Nelson, 1994). Norton et al. (1999) mentioned several factors that have contributed to the growing interest in participatory IPM: (i) information-intensive practices such as pest scouting or monitoring and use of economic thresholds have not reduced pesticide use in all cases and in some cases have increased it; (ii) pest resistance to many pesticides and pest resurgence have prompted farmers in many cases to increase pesticide dosage in order to achieve adequate pest control, resulting in higher pest control costs, lower income, and greater health and environmental risk; and (iii) traditional research and extension approaches have often failed to address the right issues concerning farmer's concerns in pest management.

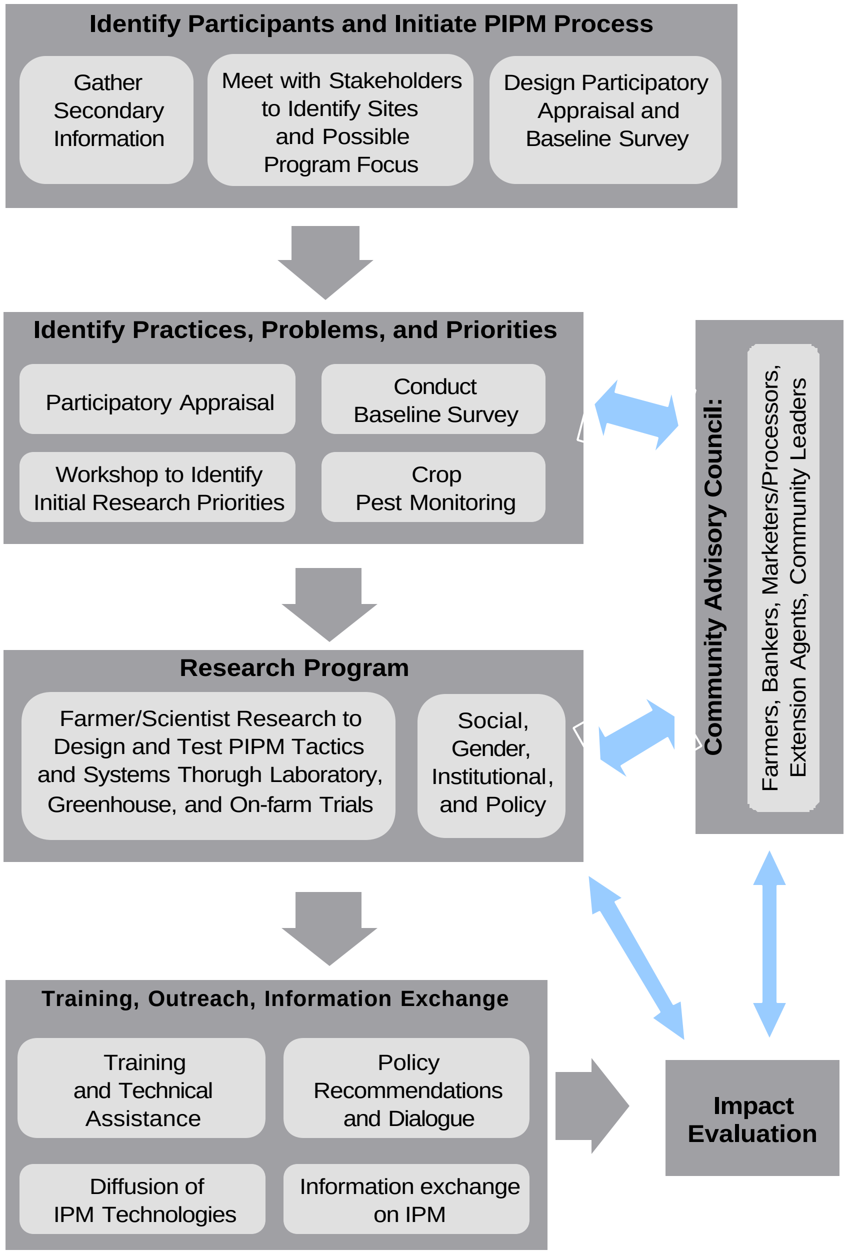


Figure 2.8 Participatory Integrated Pest Management (PIPM) Process (Norton et al., 1999)

In the participatory model, the IPM programs are viewed as an integral part of the participatory research and extension (R&E) system. The "Farmer-Field-School" (FFS) applied extensively initially in Asia and later in Africa and Latin America (Roling and van de Fliert, 1994) and the participatory IPM (PIPM) applied and refined in several developing countries by the IPM Collaborative Research Support Program (IPM CRSP) (Norton et al., 1999), are the most prominent examples of participatory approaches to pest management decision making.

The participatory IPM is grounded in two assumptions (IPM CRSP, 1997): (i) that research design, implementation, and evaluation must be a collaborative and interdisciplinary process in which both natural and social scientists are involved and (ii) that farmers-first concept of Chambers and others (Chambers et al., 1989) must be extended to include multiple actors involved in pest management decision making such as farm managers, growers' associations, marketing agents, policy makers, and so forth. As Figure 2.8 shows (Norton et al., 1999) the PIPM process includes several steps and activities. It begins by identifying site collaborators and other stakeholders, gathering secondary information, and designing a baseline survey and a participatory appraisal.

Three major activities including baseline survey, participatory appraisal, and field monitoring of pests and beneficial organisms are implemented to establish IPM research priorities. The baseline survey serves to identify farmers' pest perceptions, pest management practices and decision making process, basic socioeconomic characteristics, and other information.

The participatory appraisal includes training of natural and social scientists in participatory methods and helps develop a preliminary assessment of research priorities. In the third activity, while the field monitoring of pests and beneficial organisms is underway, farmers and scientists work together to design, test, and evaluate IPM practices. Further, research output is produced, outreach and information exchange are promoted, and economic and environmental impacts of PIPM process are assessed.

2.3 Social Costs of Pesticide Use and Net Benefits of IPM

While the economic analysis of pesticide use and their impacts dates back to the early 1960s, the economic evaluations of IPM programs have only been undertaken for the past 25 years. Over this time period, a great number of studies have been carried out examining issues ranging from micro-level assessments of appropriate on farm use of pest control practices to macro-level assessments of market welfare costs and benefits[9]. This section does not intend to provide a thorough survey of such literature. Rather, the goal is to present evidence obtained from various studies regarding the environmental, health and economic costs of pesticide use as well as the net benefits of IPM programs.

The widespread use of pesticides in pest control since the early 1950's has contributed significantly to reducing crop losses and maintaining world food production. At the same time, pesticides have become increasingly controversial because of the risk they pose to the environment, to human health, and often to agricultural productivity in the long run. Worldwide, approximately 2.5 million tons of pesticides are applied each year with a value of $20 billion (Pesticide News, 1990). In the United States, approximately 500,000 tons of 600 different types of pesticides are used annually at a cost of $4.1 billion, including application costs. It has been estimated that losses to pests would increase by 10% if no pesticides were used at all and specific crop losses would range from zero to nearly 100% (Pimental et al., 1992). Measurable benefits of pesticide use have included a reduction in costs to farmers and processors as well as lower relative prices and increased food quality for consumers (Lichtenberg et al., 1990). However, most benefits are based only on direct crop returns. Such assessments do not include the indirect environmental, health, and economic costs associated with pesticides.

Pimental et al. (1992) conducted an assessment of costs and benefits associated with pesticide use in the United States. They estimated pesticide impacts such as human health effects; domestic animal poisonings; increased control expenses resulting from pesticide related destruction of natural enemies and from the development of pesticide resistance; crop pollination problems and honey bee losses; crop and crop product losses; groundwater and surface water contamination; fish, wildlife, and microorganism losses; and governmental expenditures to reduce the environmental and social costs of pesticide use[10].

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[9] For an extensive review of such studies see Norton and Mullen (1994) and Zilberman et al. (1990).

[10] In addition to the assessment of these indirect impacts of pesticide use, Pimentel et al. (1992) provide extensive and detailed evidence about the nature of such impacts.

The results of this assessment indicated that an investment of approximately $4 billion dollars in pesticide control saves approximately $16 billions in US crops, based on direct costs and benefits. However, as Table 2.1 shows, the estimates of environmental and social costs resulted approximately $8 billion each year.

Table 2.1 Total estimated environmental and social costs from pesticides in the United States

Impact	Cost ($ million/year)
Public health impacts	787
Domestic animal deaths and contamination	30
Loss of natural enemies	520
Cost of pesticide resistance	1,400
Honeybee and pollination losses	320
Crop losses	942
Fishery losses	24
Bird losses	2,100
Groundwater contamination	1,800
Government regulation to prevent damage	200
Total costs	8,123

Source: Pimental et al. (1992), p.757.

While users of pesticides in agriculture pay directly for only approximately $3 billion of this cost (accounting for pesticide resistance and destruction of natural enemies), society eventually pays this $3 billion plus the remaining $5 billion in environmental and public health costs (Table 2.1). The authors concluded that if the full environmental costs could be measured as a whole, the total costs would be significantly greater than the estimated $8 billion/year and therefore the perceived profitability of pesticide use would be further reduced.

As discussed in chapter 1, the research, development, and promotion of integrated pest management (IPM) programs came out of environmental and health concerns of pesticide use. The implementation of IPM practices in a given crop production system is expected to reduce the above mentioned adverse effects of pesticide use. As Norton and Mullen (1994, p. 3) put it "the implication for IPM benefits are that if pesticide use is reduced by IPM programs, then the benefits may be realized in proportion to the pesticide reduction".

Table 2.2 Examples of Successful Integrated Pest Management Applications in Developing Countries

Crop	Country	Impact
Soybeans	Brazil	Decrease in pesticide use on soybeans by 80% in seven years
Rice	India (Orissa)	Insecticide use on rice reduced
Rice	Indonesia	Pesticide use on rice reduced by more than 60%
Cotton	Nicaragua	Pesticide use reduced by one-third During the 1970s
Various Crops	Cuba	Pesticide use reduced by 80% during the 1980s

Source: Postel, 1987

The most up-to-date and comprehensive review of the literature on economic evaluation of IPM programs is that provided by Norton and Mullen (1994)[11]. Some examples of successful IPM programs applied in developing countries are provided in Table 2.2. As this table shows, the reduction in pesticide use due to implementation of IPM programs in several crops such as soybeans, rice, cotton, and so forth ranged from 33% to 80%. The results of 61 economic evaluations of IPM programs in the United States implemented in cotton, soybeans, vegetables, fruits, peanuts, tobacco, corn, and alfalfa reviewed by Norton and Mullen are presented in Table 2.3 These evaluations indicated that: (i) pesticide use, on average, decreased for seven out of eight commodities; however, the authors of this review reported that 13, or 21%, of 61 studies found increased use of pesticides with IPM; (ii) cost of production

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[11] Most of studies reviewed by these authors were carried out in the United Sates

decreased or remained unchanged in four out of five commodities for which changes in cost of production were reported; (iii) yield increased for six out of seven commodities and net returns increased in all seven commodities; (iv) monetary risk to farmers decreased in all three cases that examined risk; and (v) quality increased in four studies related to vegetables and flowers and remained the same in the other studies.

A number of IPM programs have been implemented on fruit trees including apples, pears, almonds, peaches, oranges, and grapes (Norton & Mullen, 1994, see Table 2.4; Fernandez-Cornejo & Jans, 1996; Fernandez-Cornejo, 1998; Fernandez-Cornejo & Ferraioli, 1999). Fruit IPM Programs have included several IPM techniques including scouting, cultural practices, biological controls, semichemicals, host plant resistance and so forth. Most studies of economic evaluation of IPM in fruit trees report reduced pesticide costs and higher returns with IPM (Table 2.4). However, one study on apples in New York (Napit, 1986) and one on pears in Washington state (King and O'Rurke, 1997) did find greater pesticide use with scouting programs. In another study of economic evaluation of IPM on oranges in Florida, Fernandez-Cornejo and Jans (1996), found no significant differences between IPM adopters and nonadopters with respect to yields, profits, and insecticide applications.

Olive IPM programs have been implemented in most Mediterranean countries during the last 35 years. According to Katsoyannos (1992), the progress in olive IPM in the Mediterranean region is largely the result of efforts by several international organizations including FAO, United Nations Development Programme (UNDP), European Union- funded International Olive Oil Council (IOOC) and so forth. However, the Albanian olive sector was not part of any of those regionally-funded olive IPM programs due to the extreme political and economic isolation the country experienced during the communist regime. The adverse effects of such isolation are quite striking even to date if one refers to the current IOOC olive production statistics which still do not include Albania.

Much scientific information needed for IPM development in olives has already been obtained from research activities carried out with the support of these international organizations. For examples, as Kastoyannos (1992, p. 86) pointed out, IPM research and development for major olive pests has provided significant information regarding (i) sampling and monitoring (trapping, accumulative degree-day calculations); (ii) forecasting, economic thresholds and economic injury levels; (iii) biological control; (iv) cultural practices; (v) behavior-modifying chemicals (sex-pheromone, food-lure traps, mass trapping, mating disruption, deterrents, repellents); (vi) sterile insect release; (vii) symbiosis disruption; and (viii) pesticide selectivity. In addition, generalized technical advice such as information on bait sprays, avoidance of spraying for *B. oleae* during the hot summer months, pruning for *S. olaea* and so forth, have been put into practice in wide areas or have been included in experimental field trials in specific locations.

In Albania, no olive IPM program has been implemented for the last four decades. Nevertheless, scattered IPM practices have been applied from time to time. A recent publication reports some action thresholds that have been used for controlling olive fruit fly in formerly socialist co-operatives and state farms in Albania (Isufi, 1999). However, it is not clear if these action thresholds have resulted from the experiment field trials conducted in Albania or elsewhere. The IPM CRSP program currently underway in the southern olive growing region, whose potential economic impacts this study aims to estimate, marks the first formal olive IPM program in Albania. Being an open country, Albania now has the full potential to take advantage of the experience of other Mediterranean countries in development and implementation of olive IPM programs. Olive IPM research carried out in some developed countries such as Italy, Greece, Spain, and Portugal, may prove especially valuable for Albanian conditions.

The review of literature on olive IPM in Mediterranean countries including Albania revealed no economic evaluation of olive IPM programs. Out of 535 olive-related studies and literature sources cited in a recent FAO publication entitled “Olive Pests and Their Control in the Near East”, none refers to the economic evaluation of olive IPM programs.

Table 2.3 Summary of Results of Farm-level Economic Evaluation of IPM Programs in USA

Commodity	States	Number of Studies	Average Percent Change in Pesticide Use[a]	Percent Change in Production Cost with IPM[a]	Percent Yield Change with IPM	Percent Change in Net Returns Per Acre[a]	Level of Risk with IPM
Cotton	TX, GA, MS, NC, SC, LA, MO, TN, AZ, NM, CA, AR	18	-15	-7	+29	+79	Decreased
Soybean	NC, VA, MD, GA, IN	7	-35	-5	+6	+45	Decreased
Corn	IN, IL, & 10 other states	3	+20	+3	+7	+54	-----
Vegetables and Flowers	CT, CA, MA, TX, FL, OH, NY, HI	15	-43	Quality increased in 4 studies and remained the same in others			
Fruits	NY, MA, WA, NJ, CA, CT	8	-20	0	+12	+19	-----
Peanuts	GA, TX, OK, NC	5	-5	-5	+13	+100	-----
Tobacco	NC	2	-19	-----	0	+1	-----
Alfalfa	OK, WI, Northwest	3	-2	-----	+13	+37	Decreased
Unweighted Average[b]			-14.9	-2.8	+11.4	+47.8	Decreased

[a] For those producers that adopted the specified IPM practices compared to those that did not

[b] Weighting is not possible without an accurate accounting of the acreage affected for each commodity in each state

Source: Norton and Mullen (1994)

Table 2.4 Results of Economic Evaluation of IPM Programs in Fruits and Nuts

Authors	State	Commod.	Type of IPM Practice	Percent Change in Pesticide Cost	Percent Change in Production Cost with IPM	Percent Change in Yield	Percent Change in Net Returns Per Acre	Level of Risk with IPM
Napit (1986) and Rajotte et al. (1987)	NY	Apples	Scouting Monitoring	-15 to +14	+8 to +15	+3 to +21	+30 to +36[a]	-----
Napit (1986) and Rajotte et al. (1987)	MA	Apples	Scouting	-29	-5	+12	+5 to +6[a]	-----
King and O'Rurke (1977)	WA	Apples Pears	Scouting Scouting	-43 +7	-10 +20	----- -----	----- -----	----- -----
Rosie et al. (1977)	NJ	Apples	Monitoring Cultural	-12	-1	-----	-----	-----
White and Thompson (1982)	NY	Apples	Scouting	-24	-14	-----	-----	-----
Barnett et al. (1978)	CA	Pears	Scouting	Decrease	-----	-----	-----	-----
Hendley and Hoy (1987)	CA	Almonds	Predators Scouting	-41	-5 to –10	0	-----	-----
Adams and Los (1990)	CT	Apples	Scouting Monitoring Beneficials	-18	-----	-----	-----	-----

[a] Price was also higher due to quality change

Source: Norton and Mullen (1994)

2.4 Economic Assessment of IPM Programs

This section discusses techniques used for evaluating farm level and aggregate economic impacts of IPM programs. Economists have developed impressive analytical tools for economic evaluation and priority setting of agricultural research. Several studies have been carried out to assess benefits and costs of IPM adoption to the producer and society as a whole. Most of these studies have assessed the impacts of IPM adoption on producer profitability. A few examine the social welfare impacts of IPM adoption using changes in producer and consumer surplus. This information in turn is used to analyze the distribution of benefits and costs of IPM adoption among producers and consumers, regions, and socioeconomic groups.

2.4.1 Techniques Used to Measure Farm Level Impacts

Farm-level economic evaluation of IPM programs is concerned with: (i) choice of alternative pest control strategies, and (ii) optimal level of pest control by a particular practice or set of practices (Norton and Mullen, 1994). The primary method of estimating the farm level impacts of IPM adoption is budgeting analysis (Norton and Mullen, 1994). Other methods used include: pay-off matrices; first-degree stochastic dominance (SD), second-degree SD, and generalized SD; economic thresholds; mathematical programming; dynamic optimization, and econometric methods[12].

Many studies apply budget analysis for evaluating farm-level impacts of IPM programs. These studies have used various measures of expected profit (Swinton and Williams, 1998). Some studies use gross revenue minus costs of IPM adoption, while others include additional production costs. These measurement differences affect comparability of results across studies. Additional concerns arise with some of the underlying assumption of estimated budgets such as constant output-input mix, constant prices, lack of validation techniques and so forth. Lacewell and Taylor (1980) also note several problems associated with partial budgeting. The main shortcoming of the approach is

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[12] Several studies which use some of these methods were discussed in section 2.2 of this chapter

that one must subjectively specify how much acreages, production, price and other factors will change. Such subjective specifications are a drawback only because it is not always made clear how the estimates were obtained.

Many of the studies on economic impact assessment of IPM programs reviewed by Norton and Mullen (1994) have used budgeting analysis. Casey et al. (1975) used enterprise budgets to estimate the economic and environmental impacts of pest control strategies for cotton production in Texas. An enterprise budget generator was used to develop per hectare cotton budgets for each pest control strategy examined. The results of the experiment were extrapolated onto the entire study region and region-wide changes in costs, returns, yields, and pesticide use were estimated. The authors estimated that the new pest management strategies, if applied to all cotton hectares in the Texas Department of Correction cotton farms, would lead to an increase in yields and producer net returns and to a reduction in pesticide use. Similarly, Larson et al. (1975) used the Oklahoma State University crop and livestock budget generator to evaluate the economic, environmental, and energy use impacts of short season cotton production in the Texas Lower Rio Grande Valley. Enterprise budgets were used for baseline data. Tables compare the two methods' production characteristics for irrigated cotton and insecticide use, costs and returns for irrigated and nonirrigated cotton.

Rajjote et al. (1985) used partial budgeting to evaluate a pest management program developed for Virginia soybean producers. The results showed a decrease in the total variable cost of insect suppression, $7.94 net savings per acre in the production of full season soybeans, and $6.82 net savings per acre for double-cropped soybeans. Similarly, Trumble et al. (1997) constructed partial budgets to evaluate economic and environmental impacts of a sustainable integrated pest management program in celery. Experiments were conducted first on celery experimental plantings and later on commercial fields, in Orange County, California, to compare the benefit of chemical-based pest control practices with an IPM program based on an insect pathogen, *B. thuringiensis*. The IPM program generated a net profit more than $410/ha higher than that of the grower's chemical program. The increase in per hectare net profit was achieved by using 40% less conventional pesticides.

Napit et al. (1988) developed average crop budgets for several commodities in eight States (IN, VA, GA, NY, NC, MA, MS, TX). The authors conducted t-tests to test the budgets for significant differences in mean return to management per hectare and mean pesticide costs per hectare. The results of this analysis showed higher returns and less variability of per acre returns for users of IPM as compared to non-users.

In some impact assessment studies, budgeting techniques are applied as data generating tools to be used with other analytical methods. For example, Green et al. (1985) used budget analysis combined with stochastic dominance analysis to examine the effect of farmers' risk averseness on the choice of soybean pest management strategies. Results from comparisons of both expected net revenue and net revenue risk revealed that all of the IPM strategies dominate conventional pest management. In other words, producers were found to prefer strategies involving IPM practices rather than pesticide-based pest control practices. Also, Rajjote et al. (1985) used data from estimated partial budgets for soybeans to develop a linear programming model of U. S. agriculture to compare the economic impacts of IPM and traditional methods for insect control in soybeans.

Risk and uncertainty, arising due to biological, technical, or economic factors, can be a concern to farmers in their decision to adopt IPM practices. Several authors have attempted to examine the impact of IPM practices on the variability of farm profits. Two general approaches have been used to evaluate the attractiveness of alternative pest management practices under risk (Swinton and Williams, 1998). One consists on developing a money-based measure of risk. The other is using risk efficiency criteria. The former can be applied if farmers' risk preferences are known and then a risk weighted "expected utility function" can be calculated. Efficiency criteria allow for a partial ranking of choices or outcomes given certain constraints on the preferences of farmers and in some cases the probability distribution of alternative outcomes (Barry, 1984).

The three efficiency criteria applied in several studies reviewed by Norton and Mullen (1994) include: (i) first-degree stochastic dominance (FSD), which ranks distributions for all decision makers; (ii) second-degree stochastic dominance (SDD), which ranks distributions for risk-averters only; and (iii) generalized stochastic dominance (GSD), which is used to determine whether or not all producers in more narrow sets of risk preferences will prefer one cumulative distribution of net income associated with a pest control strategy or another, or have no preference. However, many distributions are left unranked with the first and second-degree SD. Studies that have employed the efficiency criteria include Green et al. (1985), Musser et al. (1981), Moffit et al. (1983), and McGuklin (1983).

Dynamic optimization models have been used in the economic evaluation of pest management studies since the 1970's (Shoemaker, 1973; Hueth and Regev, 1974). However, such studies focused on optimal pesticide use conceptually without any application with empirical data. Zacharias and Grube (1983) were the first to employ dynamic programming to examine optimal management strategies for control of corn rootworm and soybean cyst nematode in Illinois by using empirical data. Nevertheless, as Norton and Mullen (1994) noted the widespread empirical application of dynamic programming models and Stochastic Dominance techniques is constrained by the inherent complexity of these methods.

2.4.2 Techniques Used to Measure Aggregate Impacts

Unlike impact evaluation studies in other areas of agricultural research and development, which are numerous, to date only a few studies have addressed the evaluation of aggregate economic impacts of IPM programs. Moreover, most of such studies present theoretical models and discussion with little focus on empirical applications. According to Norton and Mullen (1994) the paucity of empirical work of estimating aggregate economic and environmental benefits of IPM programs can be explained by: (i) location specificity of each IPM program, (ii) difficulties in assessing environmental effects of pesticide use, and (iii) problems with respect to estimation of the value of benefits and costs that are incurred in the market setting.

Economists have developed a set of well-established techniques for evaluating aggregate economic impacts of agricultural research. Alston, Norton, and Pardey (1995) provided the most up-to-date, comprehensive, and in-depth review of methods for economic evaluation of agricultural research impacts and priority setting, which are applicable for economic evaluation of IPM. Looking at impact evaluation studies that have been carried out not only in the IPM area, but also in other areas of research, many of these methods have been refined and modified to fit the specifics of a given program and/or area of research. As a result of this work, valuable methodological guidelines have been established in the field of impact evaluation studies. Nevertheless, the limited number of studies with respect to evaluation of aggregate economic and environmental impacts of IPM suggests that more rigorous methodological frameworks and protocols are needed for IPM evaluation.

Two broad approaches have generally been used to measure the economic impacts of agricultural research[13]: economic surplus approaches and econometric approaches. Since interest for this study is primarily in methods that can be used in ex-ante impact evaluation studies, econometric approaches will be reviewed briefly while economic surplus methods will be given special attention. Referring to Figure 9, both approaches aim to estimate the research (knowledge) production function (2.7), which relates changes in agricultural output due to current and past investments in agricultural research and extension as well as current flows of conventional inputs and uncontrolled factors (Alston, Norton, and Pardey, 1995, p.27).

$$Q_t = q(X_t, W_t, H_t, Z_t, R_{t-r}, E_{t-e}) \qquad \text{for } r, e = 0 \text{ to } \infty \qquad (2.7)$$

Where: Q_t – agricultural output in time t, X_t – conventional inputs, W_t – weather, H_t – human capital variables, Z_t – Infrastructural and institutional

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[13] This section draws mainly from Alston, Norton, and Pardey (1995) unless otherwise cited.

variables, R_{t-r} – research investment variable (r-maximum research lag), E_{t-e} – Extension investment variable (e – maximum extension lag).

Econometric Approach

Econometric methods have been used to directly estimate the relationship between past investment in agricultural research and extension and agricultural productivity in equations similar to equation 2.7. Research expenditures can be included with conventional inputs in production functions. Specifically, estimation of effects of past investment in research on measures of output, profit, or costs provide comprehensive indicators of the impact of past research investments. Thus, econometric methods are used in ex-post impact evaluation studies of research. The estimated coefficient on the research variable is used to calculate the marginal product of research and the marginal rate of return to research investment. As shown in Figure 2.9, econometric approaches include the use of parametric, non-parametric, and index-number methods for estimating the research-induced savings in costs or gains in output or profit due to changes in technology.

Parametric Methods

Parametric methods require specification of an explicit functional form that relates inputs to outputs. Colman (1983) classified econometric approaches to estimating supply functions into three broad categories: primal models, dual models, and direct single-equation models.

The primal approach involves estimating either production functions (in which output is the relevant dependent variable) or productivity functions (in which output is expressed per unit of aggregate input) and then imposing upon those functions some behavioral assumption in order to deduce the implied supply function.

Alston, Norton, and Pardey (1995) note several model specification and estimation problems associated with empirical applications of primal models including: (i) simultaneity between inputs and outputs that arises when input

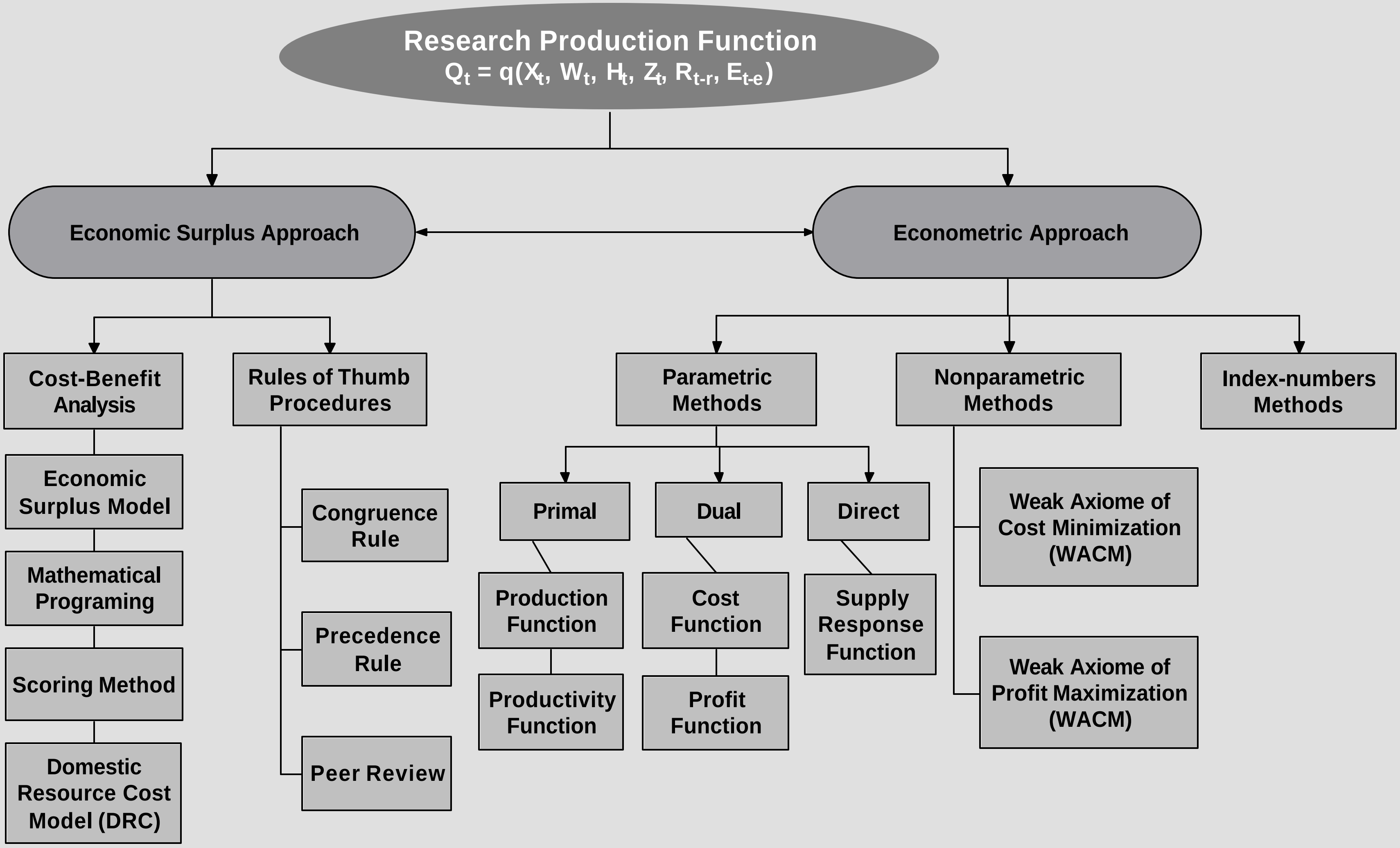

Figure 2.9 Methods for Assessing Economic Impacts of IPM Programs.

choices are jointly endogenous with output; (ii) multicollinearity that occurs when all of the explanatory variables tend to move together (a common feature of highly trending time series data such models use), making it difficult to isolate statistically the effects of any particular variable on output; and (iii) omitted variable bias that arises when variables related to some conventional inputs (see equation 2.7), human capital, and weather are not included in the model and their effects are left as part of unexplained residual. When such problems are not addressed, parameter estimates may be biased, inconsistent, and/or inefficient.

Additionally, other issues such as flexible versus inflexible functional forms, research lag structure, depreciation of knowledge stock, data requirements and so forth are discussed extensively in studies of returns to research that have employed primal models (Griliches, 1964; Bredahl and Peterson, 1976; Scobie and Eveleens, 1987).

Once the estimated production function has been obtained, the parameter estimates can be used to partition the total output into one part that is explained by conventional inputs, another part that is explained by research expenditure, and an unexplained residual. Next, value of the additional output due to research for each year in the time series being studied is calculated by multiplying the estimate of the quantity that is attributable to research by the corresponding output price. Finally, the stream of annual benefits is compared to the corresponding stream of research expenditures, using conventional budgeting methods to compute net present value, cost benefit ratio, or internal rate of return[14].

The d*ual approach* is based on the correspondence that exists between a firm's production function and its profit, cost, factor demand, and supply function under assumptions of perfect competition, cost minimization or profit maximization, and certain regularity conditions (Chambers, 1988). Dual models estimate: (i) a cost function and its corresponding input-demand functions, in which behavioral assumption are imposed, and then derivative properties are

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[14] For more details on econometric measurement of research-induced supply shift see Alston, Norton, and Pardey (1995, p. 334 -338).

used to derive supply response; or (ii) a profit function as well as its input-demand and corresponding output supply functions. In the empirical applications of duality research expenditure variables are included in either a profit function or a cost function and in the associated systems of factor demands and/or output supply equations.

Since the 1970s, when flexible functional forms and duality models of production emerged as two related innovations in applied production economics, the dual approach has been prevalent in empirical work (Chambers, 1988). Dual specifications, most often based on locally-flexible functional forms (such as the translog function) have several advantages over primal models (Lopez, 1982; Pope, 1982; Young et al., 1987; Chambers, 1988):

(i) Primal models yield input demands and output supplies by solving first order conditions (FOCs). This cannot be done analytically for many functional forms. The dual formulation has some derivative properties, which yield reduced forms of input demands and output supply. With dual cost functions, these derivative properties permit the estimation of a system of equations comprising the cost function and the system of output-constrained factor-demand functions. With a profit function, the dual approach leads to the estimation of Marshallian input-demand and output-supply functions;

(ii) The primal approach always requires twice-continuously-differentiable production function. But this property does not hold for all types of technology. Leontief production function is one such case, which nevertheless can be used in dual models;

(iii) Unlike primal models in which multicollinearity might arise (as explained above), dual models estimate cost or profit functions using input and output prices rather then their quantities. Using price data permits more precise econometric estimates of technology parameters because often there will be less multicollinearity among factor prices than among factor quantities;

(iv) The dual approach generally imposes fewer restrictive assumptions about the technology than the primal approach. However, as Alston, Norton, and Pardey (1995, p. 111) note “the dual approach allows a relatively flexible specification of the technology, but the price of this flexibility is the imposition of behavioral assumption that are of questionable applicability in an agricultural setting characterized by uncertainty and dynamics”; and

(v) Duality offers computational convenience in deriving input demand and output supply functions, demand and supply elasticities, and partial elasticity of substitution.

Nevertheless, dual models are not without shortcomings (Pope, 1982). In multiproduct cases, the problem of co-linear prices might arise. Duality works poorly when the objective function is nonlinear in parameters. Imposition of behavioral restrictions on cost and/or profit functions requires the use of Generalized Least Square (GLS) or Maximum Likelihood (ML) procedures. Sometimes, these are not possible to use when the required software is not available. Additionally, elasticities computed with dual cost functions are short-run in nature; if firms are allowed to adjust output in response to input prices, changes in elasticities will be higher in absolute value (Chambers, 1988). There have been several empirical applications of dual models to the agricultural sector[15]. However, only one study carried out by Huffman and Evenson (1989) included explicit research variables in the model. As with the production function models, the estimated parameters from the dual profit or cost function can be translated into measures of a research-induced supply shift.

Direct single-equation supply models are usually applied in cases of evaluating research impacts for a particular commodity. A number of studies have estimated commodity supply functions directly, with past expenditures on agricultural research and extension included as arguments (Zentner, 1985; Otto, 1981). According to Alston, Norton, and Pardey (1995, p.114), the direct estimation of a supply response model may be a better alternative than estimation of primal models because it allows the dynamics of supply response to price to be modelled in some detail along with the dynamics of supply response to research.

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[15] See Alston, Norton, and Pardey (1995) for a thorough review of such studies.

Nonparametric Methods

As discussed above, the estimation of research-induced supply shift or cost-reduction using primal, dual, or direct methods is related to a number of concerns about the selection of functional forms, specification of technical change, the ways to include research expenditure variables in the model, and choosing the right research lag structure. Nonparametric methods for evaluation of research are so named because they avoid the use of functional forms. Thus, this approach avoids imposition of functional form as a joint hypothesis. Instead, it checks data for consistency with axioms of rational producer behavior (Varian, 1984). The two axioms are the Weak Axiom of Cost Minimization (WACM) and the Weak Axiom of Profit Maximization (WAPM) (Varian, 1984). One example of application of this approach in research evaluation is a study carried out by Chavas and Cox (1992).

Index-number Methods

Index numbers are used extensively in economics as aggregating devices. In research evaluation studies, index-number procedures can be used either directly or in conjunction with econometric approaches to assess sources of growth in agricultural output or agricultural productivity. Using index-number procedures, the share of the growth of output or “total” factor productivity attributable to investments in agricultural research can be identified.

Economic Surplus Approach

The economic surplus approach estimates benefits from research in terms of the change in consumer and producer surplus that results from a research-induced shift in commodity supply. The change in economic surplus (consumer surplus and producer surplus) is the most commonly used measure for analyzing welfare impacts of agricultural research in a partial-equilibrium framework (Davis, Oram, and Ryan, 1987). Economic surplus approaches are used in both ex-ante and ex-post studies of research evaluation. Most methods employed in evaluating the economic benefits generated from agricultural research, as shown in Figure 2.9, use the concept of economic surplus. Even in the case of the econometric approaches, the estimation of research-induced gain in output or cost reduction is an implicit economic surplus analysis that makes extreme assumptions about market conditions (assuming either perfectly inelastic or perfectly elastic supply) (Alston, Norton, and Pardey, 1995).

Within the group of economic surplus approaches there are a number of economic surplus-based models as well as several “rules of thumb” procedures that are applied in agricultural research evaluation and priority setting in general and in IPM evaluation studies in particular (see Figure 2.9).

Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is a systematic, quantitative method of assessing the stream of costs and benefits of alternative research programs over their life cycle. It is based on a standard economic framework for project analysis. Often, cost/benefit analysis is a ratio analysis; the relationship between benefit and cost is directly expressed as the quotient of one divided by the other. The technique has its origins in economic feasibility studies of public infrastructure projects such as dams and levees (Mishan, 1976). Its use has grown in evaluation of various agricultural programs and projects worldwide.

Cost/Benefit analysis to assess aggregate impacts of agricultural research involves balancing the benefits, which a research project produces against the cost of producing that benefit. The CBA is done in three steps: (i) estimation of potential for generation and adoption of technologies under each research project, (ii) identification and quantification of the stream of economic benefits and costs associated with the research project over its life cycle, and (ii) calculation of net present value, internal rate of return, or benefit-cost ratio using discounted benefits and costs of each project (Norton and Mullen, 1996).

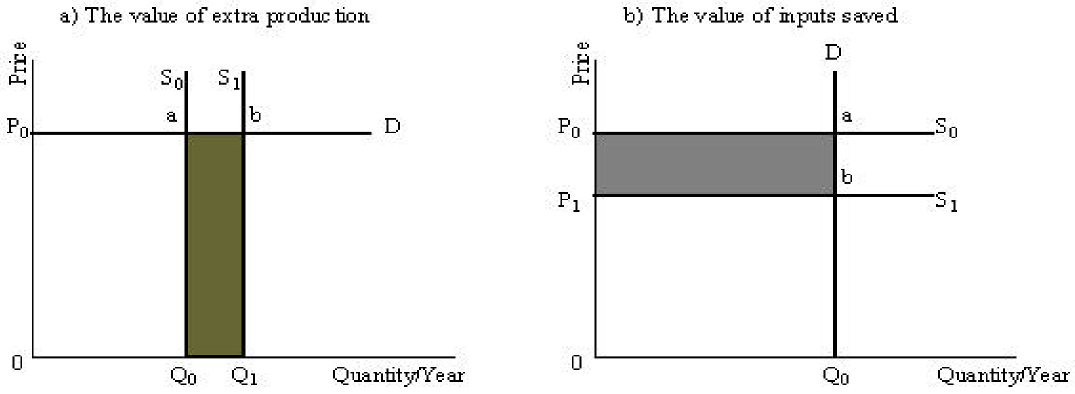

Figure 2.10 Implicit assumptions in cost-benefit analysis (Alston, Norton, and Pardey, 1995, p. 55)

Referring to Figure 2.10, the simple basic cost/benefit analysis uses one of the two following assumptions (Griliches, 1958): (i) the gain in output due to research is valued at a single market price assuming a perfectly inelastic supply curve that shifts against a horizontal (perfectly elastic) demand curve, or alternatively (ii) the research-induced cost reduction is calculated at the current level of output assuming a perfectly elastic supply curve that shifts down against a vertical (perfectly inelastic) demand curve. The change in economic surplus is equal to abQ_1Q_0 (case a) and abP_1P0 (case b).

Viewed from this perspective, benefit measures used in a CBA places all weight on the efficiency objective of agricultural research. That is, they consider only total benefits of agricultural research and rules out any price response due to research-induced supply shift, thus ignoring the distribution of benefits among various groups.

Economic Surplus Model

The economic surplus model (ESM) evaluates the economic impacts of research through its impact on commodity supply. For each research activity, the ESM estimates physical impacts of research in terms of increase in yields or reduction in per unit cost and translates them into shift in the supply function. Next, the effect of the supply shift on the market equilibrium (price and quantity) is calculated, and then total research benefits and their distribution between producers and consumers are computed. Once changes in economic surplus are calculated or projected over time, benefit/cost analysis can be conducted in which net present values, internal rate of returns, or benefit/cost ratios are calculated.

A number of assumptions have to be made on functional forms of demand and supply, nature of supply shift, demand and supply elasticities, nature of technical change, research and adoption lags, adoption patterns, research depreciation, uncertainty, and so forth. Alston, Norton, and Pardey (1995) presented a thorough review of the basic economic surplus model used for research evaluation and then elaborate several refinements to the basic model to account for a variety of market situations, including those influenced by government policies.

The ESM can be used in both ex-post and ex-ante research evaluation studies. It is deeply rooted in welfare economics and is based on a consistent theoretical framework. Unlike simple cost/benefit analysis, the ESM allows for price response to research-induced shifts in the quantity of commodity production and the apportionment of research benefits between producers and consumers as well as other target groups. It is the most data intensive method, and it requires a good understanding of economic theory, a high level of sophistication, and special skills in data manipulation. It can easily be combined with scoring and mathematical programming models when multiple objectives are involved as well as with econometric approaches. When implemented consistently with a sound economic framework, it provides more reliable estimates of aggregate net benefits of IPM programs as compared to other related methods.

Another advantage of economic surplus analysis is its ability to incorporate other changes in the commodity system into the evaluation framework such as population growth, income changes, area expansion, research spillovers from other regions, and changes in external and internal trade policies (Mills and Kamau, 1998). However, it imposes strong assumptions and calculations are not easy to follow for noneconomists. Substantial expenditures are incurred in the process of collecting and processing economic and technical data. In an ex-ante setting, the elicitation process of expert judgments needs to carefully consider all potential biases (see chapter 4).

Mathematical Programming Model

While cost/benefit analysis and the economic surplus models focus on the evaluation of agricultural research based on a single-criteria, namely efficiency, there are other methods, such as mathematical programming and scoring methods, that incorporate multiple criteria (efficiency, equity, sustainability, food security and foreign exchange) in the evaluation of alternative agricultural research programs.

The mathematical programming can be used to choose the best research projects or themes through mathematically optimizing a multiple-goal objective function, given the resource constraints. This method uses the same information as the cost/benefit analysis, but selects an optimal research project rather than ranking projects. In order to set priorities among research projects, mathematical programming can be used to identify the projects that maximize the research program goals given budget, human resources, state of knowledge, and other constraints in the system. Application of mathematical programming to research resource allocations involves the following steps (Alston, Norton, and Pardey, 1995): (i) designing the mathematical programming model, (ii) compiling information and calculating the coefficients in the model, (iii) running the model, and (iv) using the results to develop plans.

The use of mathematical programming for research evaluation and priority setting gives more reliable results when it is combined with measures of benefits derived from economic surplus analysis. One such application is the recent study carried out by Mutangadura and Norton (1999) for evaluating and prioritizing various agricultural research projects under multiple objectives in Zimbabwe. Despite its appealing features as a more quantitative formal method than some other short-cut procedures that will be discussed below, mathematical programming has rarely been applied to assist with research evaluation and priority setting at the strategic level. This is because of its high level of sophistication, data needs, skill requirements, computer software needs, and the lack of transparency.

Scoring Methods

Scoring is another method that allows for consideration of multiple objectives in the process of agricultural research evaluation and priority setting. It is a shortcut procedure that ranks a set of research program alternatives according to multiple criteria. Application of scoring method for research prioritization involves the following steps (Norton, 1993; Mills, 1998): (i) selecting a set of broad research objectives, (ii) establishing measures of research contributions to the attainment of those objectives, (iii) assigning weights to be given to each evaluation criteria, and (iv) combining criteria weights and measures to derive a final composite "score" for each research program alternative and a list of research priorities.

The scoring method uses less information than is required by a mathematical programming model. It is straightforward, participatory, and can be applied without any special training, yet it requires a more complete understanding of basic economic principles and the agricultural systems being evaluated than is sometimes recognized. As Alston, Norton, and Pardey (1995, p. 464) note "the purpose of shortcut procedures is to foster the development of an institutionalized 'economic way of thinking' about research; but if economic principles are absent from the process, even that purpose will not be served." Under these circumstances when economics is ignored, it is easy to misuse the scoring method and come up with crude, unreliable, and misleading evaluation results.

Despite these shortcomings, the scoring method has been applied more than any other formal method for ranking research priorities in developing countries. This widespread use may be explained by the fact that the method may give good approximations to research contributions when data, time, and analytical capacity are limited (Norton, 1993). Moreover, as Mills (1998, p. 69) points out, it is better to have estimates of research contribution obtained from a carefully constructed scoring model than estimates derived from a relatively rigorous model, like economic surplus, that is poorly implemented.

Domestic Resource Cost Model

Domestic resource cost (DRC) is another method that has been used for agricultural research priority setting. It is a single-criterion procedure. The DRC model involves calculating the ratio: $A/(B\text{-}C)$, where A is the social value of non-traded inputs used to produce a unit of the commodity, B is the social value of gross output and C is the social value of traded inputs used to produce the commodity (Tower, 1984).

Once the DRC ratio is calculated for each research project, the ratios are used as a cost/benefit ratio to arrive at a list of research priorities. If the DRC ratio is less than one, then it is socially desirable to conduct research project. If the DRC ratio is greater than one, it is not socially desirable. Alston, Norton, and Pardey (1995) emphasize that the DRC model has several shortcomings. It ignores the number of units (hectares, animals) to which the research benefits will apply. It also ignores the probability of research success on a particular commodity as well as the adoption rate of research results. Nevertheless, the DRC analysis provides a relatively simple measure of research contribution valued at its true social value.

Rules of Thumb Procedures

Often, application of more formal approaches, like cost/benefit analysis, economic surplus, mathematical programming, for evaluation of agricultural research may not be feasible due to lack of financial resources, data, analytical skills, and/or computational capacities. To deal with such cases, simpler and cheaper shortcut methods including congruence analysis, peer review, and precedence, have been applied to obtain measures of research contribution as well as assist with priority setting.

The general view is that these are crude or "rule of thumb" procedures that lack the economic rigor as compared to more formal methods discussed above. Further, it is argued that a good understanding of agriculture or economic principles is not necessary in order to apply these procedures. Alston, Norton, and Pardey (1995, p. 465), however, disagree with these views emphasizing that "simpler, shortcut methods, may be different in practice, but ought not to differ in principle". They point out that although various research evaluation methods may lie at different points along a spectrum of varying detail and effort, still all of these methods rest on a single theoretical foundation.

Congruence Analysis allocates total available research funds to commodities in the same proportion as their existing contribution to the agricultural domestic product or some other measure. The congruence model can be used to compare resource allocation to research by commodity, by factor, by production stage, by region and among disciplines. For example, if wheat represents 20% of the total value added in agriculture and maize 10%, then wheat would receive twice as much research funding as maize.

Boyce and Evenson (1975) defined the following congruence index (C):

$$C = 1 - \sum_{i=1}^{n} \left(S_i - RS_i\right)^2 \qquad (2.7)$$

where: S_i= share of each commodity *i* in total value of output and RS_i= share of total research expenditures spent on commodity *i*. Perfect congruence arises when C=1 for n commodities. This model is simple, cheap and transparent, yet it is based on poor theoretical logic and therefore may yield doubtful results. Additionally, it has a serious shortcoming because it favors commodities that are well-established and discriminates against new ones and those with low current value. The information required for congruence analysis depends on the measure chosen. The measure may be the value of production, area planted, number of earning income from a product, number of poor impacted and so forth.

The p*recedence model* involves allocation of research funds for each project or research area based on the previous years funding. This model is simple to apply and provides long-term continuity in the funding of research areas. Nevertheless, use of this model in research priority setting gives rise to controversial results. Allocating present and future investments to individual research projects based on their past funding figures may not always lead to a high rate of returns. Increasing research funding in those areas with greater stock of research capital may yield higher benefits than in those areas where funding has historically been limited. But this may not be true in all situations. There may be areas of research or other innovative technologies for which traditionally may not have been invested heavily in the past, yet the marginal return to these research projects can be high.

Peer Review is another short-cut method widely used in evaluating research impacts and guiding research priority setting. Sometimes, peer review is referred to as checklist method. According to this method, first a list of criteria for project selection is established; most questions address three areas: impact of research, its cost, and its feasibility. Second, a technique is chosen for eliciting expert opinions[16]. Next, individuals (experts) are asked to compare one project proposal either to another project proposal or to a group of alternative research proposals and to indicate their preference based on the list of criteria.

This is the simplest of all tools, but requires a good understanding of agricultural research and agricultural development in general. It can greatly improve the quality of research priority setting at little extra cost. Basically, personal judgments elicited from experts, through peer review, are related more to scientific merit of research project proposals than to their economic merits. The peer review or checklist method can be expanded into a scoring model by attaching weights and scores to the criteria being used.

2.4.3 Previous Studies on Aggregate Economic Evaluation of IPM

As indicated by Norton and Mullen (1994) there are only a few empirical studies that have assessed the aggregate economic impacts of IPM Programs. Most of these studies have used implicitly or explicitly either the general benefit-cost analysis framework (Ervin et al., 1983; Lacewell and Taylor, 1980; Araji, 1981; Headley and Hoy, 1987; and Enkerlin and Mumford, 1997) or the economic

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[16] Shumway (1977) discuss several of such techniques, including a committee approach, chain of command, the Delphi method, the weighted average method, nominal group technique, and interpretive structural modeling.

surplus analysis (Taylor and Frohberg, 1977; Taylor et al., 1979; Emerson and Plato, 1978; Schaub et al., 1981; Headley, 1981; Napit et al. 1988, Cox and Forrester, 1992; Beddow, 1999; and Debass, 2000).

Ervin et al. (1983) estimated the potential benefits and losses associated with a biological control program in California. Benefit/Cost (B/C) analysis was performed to compute present values of B/C streams. The value of crops in the projected infestation area was estimated via previous California crop production data. A B/C ratio of 22/1 was obtained by comparing overall program costs and expected crop losses. Based on this ratio, the authors conclude that the biological control program was highly cost effective and worthy of future investment. A similar study was carried out by Headley and Hoy (1987) to evaluate economic benefits of an integrated mite management program for almonds in California.

Lacewell and Taylor (1980) analyzed benefits and costs of switching to short season cotton varieties in three areas in Texas. Using a macro model, the authors computed changes in aggregate farm income resulting from the increase in yields as well as net social benefits associated with this program as measured by the benefit/cost ratio.

Enkerlin and Mumford (1997) evaluated the economic impacts of three alternative methods for control of the Mediterranean fruit fly in Israel, Palestinian Territories, and Jordan using a 9-year time frame. The control alternatives included population suppression using bait sprays, population suppression using massive releases of sterile male flies, and population eradication also using massive releases of sterile male flies. Costs and benefits at net present value were computed for each control option to estimate the economic indices. An 8% discount rate was used for the three territories based on interest and inflation rates in the region during 1990-1995. Costs were assessed in four ways: (i) direct damage to fruit production by Mediterranean fruit fly (MFF); (ii) indirect environmental damage by the MFF control; (iii) costs of present control programs; and (iv) costs of alternative control options. Benefits of the three control options were calculated through: (i) increase in production due to application of these alternative options for controlling the

MFF; (ii) savings in environmental costs; (iii) savings in costs of more expensive conventional control methods; and (v) market gain from comparative advantages. The results of this study revealed that the 3 area-wide control options were technically and economically feasible and all were better than the conventional control methods.

Araji (1981) conducted an ex-ante evaluation of present and future investments in IPM for several commodities in the United States. A general benefit/cost analysis was used to compute the flow of benefits and costs from each research project as well as the benefit/cost (B/C) ratio and internal rate of return. Unlike some other IPM evaluation studies that employ benefit/cost analysis, this study presents clearly the assumptions that are made regarding the adoption profiles, research and extension lags, probabilities of IPM adoption, probabilities of research success, and regional spillovers effects for the commodities considered. The results indicated that: (i) B/C ratios vary considerably by commodity (high of 191, low of –20); (ii) significant returns to investments require extension involvement in the dissemination and implementation of the result; and (iii) IPM technology is transferable, but the degree of transferability varies across crops and pests.

Emerson and Plato (1978) evaluated the benefits of controlling witchweed in the U.S. by assessing the impacts on consumer surplus and export earnings. The authors examined continuation of the current containment program, expansion aimed toward eradication, or discontinuance of the program. The results indicated that rates of return for containment were higher than for eradication. Similarly, Taylor and Frohberg (1977) used the economic surplus framework combined with a linear programming model of crop production in the Corn Belt.

Napit et al. (1988) used economic surplus analysis to assess the aggregate economic benefits of IPM programs to consumers and producers in several states in the U.S.. Changes in consumer, producer, and total net economic surplus from IPM programs were calculated assuming linear supply and demand curves, a pivotal shift in supply, no imports or exports, and a perfectly competitive agricultural sector. Net benefits of IPM programs to society were obtained by computing the internal rate of return. The results of this study revealed very high annual internal rates of return to investment in IPM (425% for Texas and 300% for Mississippi). However, consumers received most benefits due to lower prices. Additional studies using economic surplus analysis but with less explicit assumptions on the model chosen can be found in Schaub et al. (1981), Taylor et al., 1979; Schaub et al., 1981; Headley, 1981; and Cox and Forrester, 1992).

2.5 IPM Adoption

The purpose of this section is to briefly review the previous studies on IPM adoption, highlighting the stylized facts and research findings on barriers to IPM adoption and remedial strategies to remove these barriers. Some measurement issues related to level of IPM adoption are also discussed.

2.5.1 Previous research on IPM adoption process

Unlike research on aggregate evaluation of IPM programs, there are a larger number of studies on IPM adoption. Researchers of different disciplines including agricultural economists, sociologists, anthropologists, and so forth have analyzed the adoption of IPM techniques and identified key factors affecting the rate of IPM adoption for several commodities. For example, Greene et al. (1985) for Virginia soybean farmers; Weitzstein et al. (1985) for cotton producers; Napit et al. (1988) for several commodities in eight states; Thomas, Martin, and Edwards (1988) for Indiana corn and soybean producers; Kovach and Tette (1988) for New York apple growers; Harper et al. (1990) for Texas rice farmers; McNamara, Wetzstein, and Douce (1991) for Georgia peanut producers; Ridgley and Brush (1992) for California pear producers; Fernandez-Cornejo, Beach, and Huang (1994) for vegetable growers; and Owens, Swinton, and van Ravenswaay (1997) for Michigan corn growers. Examples of most recent IPM adoption studies in developing countries include Rama-Rao, Srinivasa-Rao, and Reddy (1997) for castor growers in Andhra Pradesh, India and Chittere (1998) for the adoption of IPM technologies developed by the ICIPE/UNECA integrated pest management project in western Kenya.

Sociologists conceptualize the innovation decision as a multi-stage process (Rogers, 1995). According to Rogers, five characteristics of an innovation are essential to explain its rate of adoption: (i) the perception that the innovation is better than the traditional practices, due to economic or social factors; (ii) its compatibility with tradition and past experience; (iii) its complexity; (iv) the feasibility that the innovation can be tried/experimented on a limited basis; and (v) the visibility of the results of innovations.

During the last two decades, Rogers' diffusion model of innovation has been criticized for having disciplinary blinders and failing to use a systems perspective in diagnosing farmers' problems. As Antholt (1994, p.3) points out "…the diffusion approach and "getting technology right" generally reinforced the limited, linear, and sequential view of how information and knowledge need to be developed and made accessible to farmers - that is, from basic science to applied science to technology innovations to farmer recommendations."

Recently, a new consensus has emerged relating diffusion of innovation model with other technical, economic, and institutional factors (Thomas et al., 1990; Nowak, 1992; Nowak, 1996; Fernandez-Cornejo et al. 1994). Among these latest developments, Nowak's model appears to provide important insights into the nature of the adoption process of IPM.

Nowak (1996) pointed out producers do not adopt IPM technologies because they either are unable or unwilling to do so. According to Nowak's paradigm, ability or willingness to adopt production technology is not limited to economic factors only. A rational producer will not adopt IPM technology when there is some obstacle or a situation preventing the producer from doing so. Reasons for this inability to adopt include: lack of information; high cost of obtaining information; too complex and too costly a production system with IPM; excessive labor required; a planning horizon that is too short; limited, inaccessible, or unavailable support system of resources; inadequate management skills; and limited control over adoption decisions.

Further, Nowak argued that some producers may be unwilling to adopt new practices because they may have not been convinced such practices are appropriate or will work for their farming systems. Such unwillingness on part of farmers, noted the author, may occur: when information is irrelevant or inapplicable; when new technology and farmer's production goals do not fit well; when farmers are ignorant with respect to basic economic and agronomic facts of the technology; when technology is inappropriate to the farm's physical setting; and when producers perceive a higher risk of new practices as compared to traditional practices.

From a sociological standpoint, the Nowak's paradigm explained above provides important insights into the adoption process of IPM including: (i) need to analyze IPM adoption from the perspective of producers; (ii) need to address the barriers to adoption rather than blaming the farmers for nonadoption decisions; and (iii) need for remedial strategies to remove such barriers to be based on a format consistent with capabilities of various groups of producers (adopters). However, Nowak does not present any statistical test of the factors affecting IPM adoption, nor does he elaborate the relative importance of such factors.

2.5.2 Stylized facts on incentives for and barriers to IPM adoption

There exists a consensus among experts of various disciplines involved in the process of design, development, implementation and diffusion of IPM programs regarding two major constraints to wide-scale adoption of IPM. One is the difficulties in developing an appropriate IPM program in which the components are all compatible to a given crop production system. The other is the difficulty the IPM specialists encounter in convincing producers about the advantages of the system (Wearing, 1988; Mengech et al., 1995).

The literature on IPM implementation lists several factors which serve as a stimulus to IPM adoption. From a survey conducted with more than 150 researchers and extension specialists in Europe, the United States, and Australia/New Zealand in 1985, Wearing (1988) reports that cost advantage, pesticide resistance, environmental issues, and grower hazard were rated as most significant incentives for IPM adoption. The need for IPM programs to offer cost advantages over conventional methods is most often cited as a major incentive for IPM adoption. Although environmental issues were an important concern that contributed to the development of IPM concept, it apparently has a minor impact on pest control decisions by farmers (Knight and Norton, 1989). Farmer perception of long-term benefits is rarely cited as a significant factor in IPM adoption. Van den Bosch (1978) considered the rising cost of pesticides to be an important incentive for IPM adoption. Research and extension services are seen as helping IPM adoption by reducing producers' risks, providing timely advice, and helping farmers understand the basics of IPM (Fenemore and Norton, 1985). The pesticide residue problems are mentioned as another factor promoting IPM.

Practical implementation and adoption of IPM has proven difficult because of a large number of barriers that have been identified in many regions of the world where IPM programs are under implementation. It has been reported that a variety of technical, economic, educational, institutional, and social/marketing barriers hamper adoption of IPM.

Among the technical obstacles reported by literature on IPM adoption are the complexity of IPM methodology with respect to monitoring and action thresholds and the lack of cosmetic quality standards for produce (Mumford and Norton, 1993). Financial constraints reported include: higher cost of labor associated with IPM due to complex monitoring and staff supervision; farmer perception of financial risk due to not spraying; lack of extension funds and higher cost of extension for IPM production system (Brader, 1979). Related to this, the need for more emphasis on farmer training to get the IPM message across is mentioned by several authors (Kenmore et al., 1987). Whalon and Croft (1983) add the low cost of chemical control as a percentage of total production costs as another constraint for fruit trees. Also, development of selective and less toxic pesticides is limited by high costs.

As emphasized earlier, most experts agree that IPM is a complex and multi-component innovation, which requires intensive education of end-users to insure its effective implementation and adoption. As a means to remove educational barriers, it has been emphasized the need to (Wearing, 1988): (i) expand growers education programs; (ii) strengthen training of IPM specialists and administrators; (iii) change consumer attitudes and increase their awareness of pesticide residue and environmental pollution; and (v) improve communication between farmers and IPM developers. Lack of knowledge and information of IPM developers about the perceptions and attitudes of farmers is cited to be a great obstacle to IPM implementation and adoption (Goodwell, 1984). As a result, the IPM "product" is often not designed appropriately to a particular farming system, letting farmers perceive IPM as too complex, too expensive, and too risky (Norton & Mumford, 1993).

The institutional barriers to IPM adoption most frequently identified are poor organization of scouting services; difficulty in transferring knowledge to growers; poor linkages between research, extension services, and consultants; lack of coordination, at both local and regional levels, among organizations, personnel, and disciplines (Mengech et al. 1995). Absence of social scientists on IPM teams is seen as a factor contributing to a lack of understanding of the implementation process and organization of IPM programs. Furthermore, Goodwell (1984) underscores the need to provide further social science training for extension staff and scientists. The need for collective action in IPM implementation and adoption, such as farmers' associations and cooperatives, has been identified as essential factor especially in cases where pest mobility is involved (Knight and G. W. Norton, 1989; Daku et al., 2000).

Willey (1978), Perkins (1982), and MacIntyre (1987) discussed competitive advantages of chemical control over IPM, which affect the rate and magnitude of IPM adoption. These advantages include: (i) the existence of an established infrastructure (policy, legislation, distribution, information and so forth) for pesticide supply and use; (ii) a high ratio of chemical sales personnel, distributors, and advisors to IPM extension personnel; (iii) much of the social, environmental, and resistance costs and risks of chemical use are hidden or long-term; (iv) farmers have experience, confidence, and satisfaction with the use of pesticides; (v) chemicals are simple and easier to use and farmers have equipment to apply them; (vi) chemical companies have marketing skills and exercise great pressure on farmers to use pesticides; and (vii) the cost of advice on chemical use is in the price of the product. Therefore, considerable social and marketable skills will be needed to "unlock" farmers from chemicals (Norton & Mumford, 1993).

Additionally, Wearing (1988) mentioned some important shortcomings of IPM as a marketable product. Such shortcomings include: its complexity; the substitution of skilled labor for capital investments; the charge for advice on pest control; the difficulties of sometimes selling higher short-term costs for long-term benefits; the perceived risk of reducing pesticide applications and tolerating pests in the crop; and frequent need for collective action rather than individual farmer action in some IPM operations. If these drawbacks are not addressed in a timely fashion, they may pose a serious hurdle in the process of implementation and adoption of IPM programs.

2.5.3 Measurement of IPM adoption

As with any program of technology diffusion and adoption, the measurement of IPM adoption is a sensitive issue for a number of reasons. An appropriate measure of adoption of IPM reflects the extent to which the goals and objectives of an IPM program are achieved. Measuring adoption provides information on efficiency of resources used in IPM and on equity (who is adopting these practices). Additionally, accurate measures of IPM adoption help obtain better estimates of economic impacts from IPM programs and increase the chances for political and institutional support of IPM programs.

Several indicators have been used to measure the adoption level of IPM practices. One is the so-called accounting measure, which consists of counting target farmers' responses to a certain innovation program (ADB, 1994). In the case of IPM, such measures include: the number of farmers adopting IPM; total hectares of farms adopting IPM; number of farmers using resistant varieties; number of farmers able to recognize natural enemies and so forth.

Proportional indicators are another way of measuring IPM adoption (Nowak, 1996). Producers are asked if they are using certain practices through yes or no questions. These dichotomous responses are then manipulated in one of three ways: (i) individuals are classified as adopters or nonadopters of IPM based on the proportion of yes to no answers; (ii) individuals are classified as to the level of IPM use according to some ordinal scale of measurement such as low, medium, or high, based on the proportion of practices used; or (iii) the extent of IPM adoption is calculated based on the proportion of applicable hectares on which the practices are applied; in other word adoption is measured as a degree of use.

Most evaluations of technology adoption continue to use a dichotomous measure of adoption. IPM adoption studies are not an exception (Thomas et al., 1990; Harper et al., 1990; McNamara, Wetzstein, and Douce, 1991; Fernandez-Cornejo, Beach, and Huang, 1994). Examples of studies that use an ordinal scale of adoption measurement include Napit et al. (1988) and Vandeman et al. 1994) that delineate producers into three IPM adoption categories: non-users, low-users, and high-users. Similarly, Kovach and Tette (1988) classified apple growers as either non, low or high adopters based on their use of monitoring devices, scouts, and special spray methods.

The use of dichotomous measures of IPM adoption has been criticized by several authors as being irrelevant and ignoring the essential features of IPM as a complex and multi-component innovation. Ridgley and Brush (1992) note that adoption of most technologies including IPM is limited, selective, and often partial. Acknowledging the idea of selective adoption, they used four components (pest monitoring, monitoring of beneficials, weather monitoring, and economic thresholds) measured on a standardized scale of 1-5, with 5 representing the highest level of adoption, to study factors affecting adoption of IPM practices for pears in California. McDonald and Glyn (1994, p. 220) emphasize that researchers must recognize that partial adoption is not equivalent to non-adoption because as they put it “farmers adopt specific techniques, not IPM.”

Recently, Mullen (1995) developed an "algorithm that transcends crops and locations but takes into account the proportion of available practices employed by producers and the importance of each class of pests." (Mullen, et al., 1997). First, a specific crop and growing region is identified. Next, the classes of pests that pose an "economic threat" to the producers of the crop are identified and assigned an indicator of the importance from 0 to 3. Finally, the numbers of alternative pest control practices that are cost effective for controlling each pest type are identified. Using this information, a degree of integration (DOI) is calculated as:

$$DOI = \frac{\sum_{C=1}^{n}\left(\frac{\text{employ}_c}{\text{available}_c} * \text{importance}_c\right)}{\sum \text{importance}_c} \qquad (2.8)$$

Where: n - the number of relevant pest classes, importance – importance_c of controlling each class (0,1,2 or 3), available_c - number of IPM practices available to control class c, and employ_c - number of IPM practices producer uses to employ c.

2.6 Ending Remarks

A number of models, methods and techniques with various degrees of sophistication and detail are available for performing economic impact assessment of olive IPM programs at farm and aggregate levels. Several models that capture the farmers' pest management decision process have been discussed in this chapter including the economic threshold model, the economic optimization model, the decision theory model, the behavioral decision model, and participatory model. These models along with budget analysis are useful analytical and practical tools that describe why and how farmers make their pest management decisions and help in assessing economic impacts of IPM research at the farm level.

The review of literature revealed a limited number of studies related to evaluation of aggregate economic and environmental impacts of IPM in general and the absence of such studies on olive IPM. This suggests that more rigorous methodological frameworks and protocols are needed for economic impact assessment of IPM. As a means to guiding this process, Table 2.5 provides a synthesis of methods and techniques described above in terms of data requirements, degree of detail and sophistication, analytical capacity required, outputs, the rigor of results, and transparency of calculations.

Basically, econometric approaches are the best for ex-post evaluation of IPM and therefore are not relevant to this study. The cost-benefit analysis, economic surplus, and mathematical programming are formal methods that require reliable and detailed data, highly skilled analysts, a clear understanding of welfare economics and agricultural development. They yield more reliable results with higher degree of detail than informal methods.

Economic surplus analysis is the most powerful among the group of quantitative formal methods that can be used in both ex-ante and ex-post settings of IPM research evaluation exercise. It uses economic-based information and a consistent economic framework. It is a flexible method that allows consideration of spillover effects of research results across regions, government policies and other market conditions.

Cost/benefit analysis that uses economic surplus measures lies at the heart of techniques for measuring the aggregate economic impacts of agricultural research including IPM programs. Mathematical programming selects an optimal research project and does provide information to rank research projects. It yields more reliable results when it is combined with measures of benefits derived from economic surplus analysis. In contrast, shortcut methods including scoring are least demanding in terms of time and financial resources, data, analytical capacity and skill level. They also insure a transparent and participatory process of research impact evaluation. However, they lack a sound and rigorous economic foundation and are not as informative as mathematical programming and economic surplus analysis. Often, they are subject to expert’s value judgments and other bias yielding unreliable evaluation results.

The main conclusion derived from the brief comparative analysis of such models is that there is no “one size fits all” model to any situation. Each method has its strengths and weaknesses. In choosing which method to use for a particular situation several factors must be considered including: (i) the type of questions to be answered and purpose of analysis; (ii) the level of analysis (eg.

farm vs. aggregate level); (iii) operational aspects such as availability of data, time, financial and human resources, as well as analytical skills; (iv) the completeness and consistency in terms of the conceptual economic framework and the degree of detail and sophistication. Where data, analytical capacity, and other resources are in place, there is really no substitute for the economic surplus model in assessing economic impacts of IPM programs. As Alston, Norton, and Pardey (1995, p. 462) indicate the use of more formal methods such as economic surplus is justified as long as the additional economic benefits associated with these more complete procedures exceed the additional cost of their implementation.

Table 2.5 Main Features of Methods Available for Assessing Economic Impacts of Olive IPM Programs

Method	*Description*	*Data requirements*	*Output*	*Strengths*	*Limitations*
<u>Economic Surplus Approaches</u>					
Simple Cost-Benefit Analysis	Evaluate social welfare effects of research programs by quantifying economic benefits and costs of each program	Net yield gains Output quantity and price Adoption profiles Discount rate	BCR NPV IRR Net benefits	A standard and comprehensive framework Easy to understand Can be used in both ex-ante and ex-post evaluations	Considers total benefits only Rules out price response to research-induced supply shift Identification of economic benefits & costs may not be transparent
Economic surplus Analysis	Assess economic impacts of Research-induced supply shift in terms of economic surplus (ES); Apportion the ES between consumers and producers	Net yield gains Output quantity and price Elasticity of demand and supply Discount rate Adoption profile Probability of research IRR Success (ex-ante analysis) Population growth rate Research spillovers	Economic surplus Consumer surplus Producer surplus BCR NPV	A powerful and flexible method with a sound and rigorous economic framework Can be combined with other methods Economic based-information Most reliable estimates Can be used in both ex-ante and ex-post evaluations	Strong assumptions Expensive and complicated Requires a thorough understand. of economic principles; Data intensive; special analytical skills and computer software required Not fully transparent Calculations not easy to understand for non-economists
Mathematical programming	Choose the best research project by optimizing a multiple-goal objective function subject to resources and other IRR constraints	Input-output coefficients Costs and prices NPV	activity mixes shadow prices	A quantitative formal method Allows for multiple objectives Relatively cheap when combined with economic surplus	High level of sophistication Special data and skill requirements Lacks transparency Computer software needed Does not rank programs
Scoring	Evaluate and rank a set of research program alternatives according to multiple criteria	Research objectives Criteria and criteria measures Other information depending on criteria measures chosen	Scores Ranking	Time saving and transparent Straightforward and participatory Considers multiple objectives Minimum data and analyst skills Good approximates of research contributions	Potential lack of rigor & easy to abuse; Lack of discounting Requires a clear understanding of economic principles and agricultural systems Used in ex-ante analysis only
Domestic resource/ cost (DRC) ratio	Evaluate and rank research programs in terms of domestic resource cost ratio	Value of traded and non-traded inputs to produce the commodity Value of gross output rate	The DRC ratio Ranking	A relatively simple measure Easy to understand	Ignores the number of units to which the research benefits will apply does not consider probability of research success and the adoption

Congruence rule	Evaluate and rank research projects according to the value, of a single measure eg. the value of production	Depends on the measure chosen. In case of value Ranking of production, disaggregated commodity price and production data are required	Congruence index	Allows budget allocation Simple, cheap, transparent	Lacks economic rigor Unreliable results Discriminates against new commodities and those with low current value; Poor decision tool
Precedence rule	Rank research projects based on their respective previous year funding	Baseline value of output Baseline value of research support	Ranking Allocation of funds	Simple to apply and cheap Provides long-term continuity of research funding	Discriminates against new areas of research; Poor decision tool "Rule of thumb" procedure
Peer review	Evaluate alternative research proposals using expert Criteria judgment; experts indicate their preferences based on a list of criteria	Criteria weights Other information depending on criteria chosen	Weights Ranking	Simple, cheap, transparent Historically-based Can be expanded into scoring models	Lacks a sound theoretical logic Understanding of agric. required Not useful as a decision tool for broad research programs
<u>Econometric Approaches</u>					
Production function	Quantify aggregate rates of return for agricultural research as a whole by estimating a production function or a productivity function in which past research expenditure are included as arguments	Output quantities and prices Past research expenditures Quantities and prices of other conventional inputs	Output elasticity with respect to research "Total" marginal product of research IRR	Does not require imposition of Strong behavioral assumptions A quantitative formal method	Potential biased and inconsistent estimators due to simultaneity, multicollinearity, and omitted variable bias Used in ex-post evaluation studies only; Special data requirements Not applicable for all types of technology
Dual cost function	Evaluate research impacts by estimating duality-based specifications of cost functions with their corresponding input-demand and derived output supply functions	Input prices Output quantities Past research expenditures Variable costs	Cost elasticity with respect to research Marginal cost-saving Benefits IRR	A quantitative formal method Favorable derivative properties Applicable for any technology Less multicollinearity Data and computational convenience	Strong behavior assumptions Requires good analytical skills Special data requirements Used in ex-post evaluation studies only
Supply response function	Evaluate research impacts in a single commodity by directly estimating supply functions	Output quantities and prices Past research expenditure Other input prices	Yield gains Stream of benefits IRR	Estimates in more detail dynamics of supply response to research and price	Can be applied to single-commodity evaluation studies and ex-post evaluation studies only

Note: BCR = benefit cost ratio; NPV = net present value; IRR = internal rate of return; DRC ratio = domestic resource/cost ratio; Congruence index = (see section 2.4.2 of this chapter)

Chapter 3: Conceptual Framework

Section 3.1 Introduction

This chapter develops an integrated assessment approach for economic evaluation of olive IPM based on the relevant theory of production and welfare economics. Section 3.2 outlines main components of an integrated approach for assessing IPM programs. Section 3.3 describes methods used to examine the economic feasibility of olive IPM practices at the farm level. A closed-market economic surplus model under alternative specifications of supply, demand and zone-specific conditions is developed in section 3.4 to measure the economic benefits from IPM research-induced gains in olive output and quality improvement. Section 3.5 presents a model of IPM adoption under output uncertainty. The last section provides concluding remarks regarding the methodology.

Section 3.2 Integrated Economic Assessment of Olive IPM

The development, implementation, and adoption of IPM programs involves many economic considerations. It involves investment of scarce resources in the production of knowledge. Increasing the stock of knowledge and information on olive IPM can lead to an increase in productivity and thereby contribute to a range of economic and social objectives, especially economic efficiency and equity. Efficiency is related to research impacts on aggregate welfare. In other words, it shows whether the investment is an efficient use of resources. Equity concerns the distribution of aggregate welfare benefits. That is, it tells how the benefits and costs of IPM research and adoption are distributed among different groups within a given region or for the country as a whole.

Broadly speaking, benefits of applying IPM on olives are evident at both the olive farm and the national level. IPM program implementation on olives benefits olive growers and their farm households and society as a whole in terms of government savings, reduced environmental pollution, biodiversity, and ecological sustainability. The potential benefits of olive IPM as listed in table 3.1 are usually evaluated in terms of (i) reducing pesticide expenses; (ii) increasing yields through application of an improved pest management system; and (iii) reducing external costs, that is, adverse effects on environment, human health, and wildlife.

From the evidence presented in section 2.4 of the previous chapter, it is clear that not all potential benefits can be realized from an IPM program. There are a number of factors including crop and location specificity of each IPM program, price and pesticide policies in a given country/region, farmers' knowledge of pest management, methods used and assumptions made in each assessment study, to name but a few, which greatly affect the estimation of the magnitude and range of such effects.

Table 3.1 Potential farm-level and aggregate benefits of IPM Programs

Farm-level benefits	Social benefits
▪ Lower pesticide use ▪ Lower production costs ▪ Lower crop and crop product losses ▪ Higher yields ▪ Higher quality ▪ Lower yield variability ▪ Enhanced efficiency of other inputs used ▪ Higher net returns ▪ Better training for farmers ▪ Better access to information ▪ Conservation of beneficial organisms ▪ Reduction of pesticide resistance in pest population ▪ Reduction of pest resurgence ▪ Fewer secondary pest outbreaks ▪ Lower health risks ▪ Less ground water and surface water contamination	▪ Less government subsidies for pesticides ▪ Less government funds for pesticide-pollution control ▪ Less domestic pesticide production ▪ Fewer pesticide imports ▪ Larger savings of foreign currency due to reduction of pesticide imports ▪ Net economic benefits to producers and/or consumers ▪ Better water quality ▪ Food safety for humans and wildlife

Source: Based in part on Norton and Mullen (1994)

The economic impacts of IPM can be examined from two perspectives: before IPM research starts (during the planning phase), that is, *ex-ante,* and/or after research is completed, that is, *ex-post.* The ex-post impact assessment provides information on IPM research results to justify requests for continuing funds and support. *Ex-post* assessment contains elements of *ex-ante* analysis because, as with any research program, not all benefits of a given IPM program will be realized up to the point when the *ex-post* evaluation takes place. Most evaluation studies have used the *ex-post* approach.

The present study deals with *ex-ante* economic evaluations of olive IPM programs. *Ex-ante* impact assessment provides information on potential economic benefits of various individual projects within the olive IPM program to olive growers and the country as a whole. To do that, the study follows an integrated approach for assessing economic impacts of olive IPM programs.

In general terms, integrated economic impact assessment (IEA) refers to the economic analysis of the full range of the consequences, immediate and long-term, intended and unanticipated, of the introduction of a new technology, project, or research program (Porter and Rossini, 1983). In another definition provided by Antle and Capalbo (1999, p. 34), IEA is defined as "an application of the economic tool of benefit cost analysis, combined with appropriate data and models from production economics, environmental science, and health science". Based on this integrated assessment approach, the economic evaluation of olive IPM includes the following components: (i) assessing potential farm-level economic impacts; (ii) assessing country-wide, aggregate, or societal-level impacts; and (iii) examining factors that influence the likely rate of olive IPM adoption. Below, a framework for evaluating the economic impacts of olive IPM which considers the above components is discussed.

3.3 Farm-level Economic Impacts

An assessment of the potential impacts of olive IPM practices at the farm level should provide measures of comparison of costs and returns with and without the IPM practices. In order to carry out such an assessment, first, an examination of the main factors affecting olive profitability are examined, drawing some implications for the net return analysis of applying olive IPM. Second, methods that this study employs to obtain the measures of comparison of olive IPM impacts at the farm level are discussed. Finally, the need for examining the sensitivity of the results is emphasized.

3.3.1 Factors affecting olive profitability

Olive production is a subsistence base for a large part of the population in many Mediterranean countries including Albania. The social and economic importance of olives is related to several special features the olive crop has compared to other fruit trees. Olives are a permanent crop with unequalled adaptability and resistance. It can produce under the most unfavorable agro-geographic conditions. It can survive long periods of almost total neglect and it easily recovers from adverse effects of droughts and/or unsatisfactory cultural practices.

Being a perennial crop, olive trees have an inherent capital value. This crop gives more than one product including: table olives, olive oil, and olive byproducts such as olive paste, seeds, and leaves. The two main products obtained from olive growing are table olives and olive oil. Of the two, olive oil is economically more important than table olives. Additionally, there are some olive and olive oil processing by-products. One is the so-called olive-husk oil, which is a by-product obtained from olive oil extraction. The bulk of olive-husk oil is for industrial use. Other by-products include olive cake[17], olive residue that can be used as animal feed. Some talk about pharmaceutical value of the leaves of the olive tree (FAO, 1977).

Olives exhibit biennial bearing and take long periods to complete a full cycle. That is, each year of high yield is followed by a year of low yield. Alternate bearing is an overall response of cropping due to yearly overlapping between two successive biennial cycles. The inhibition of floral induction (for the next year) by developing fruits (of the current year) is mentioned as the major factor in the olive biennial bearing behavior (FAO, 1977). This biological feature of olive trees greatly affects the way farmers view the input-output relationship in olives. For example, biennial bearing serves as a disincentive to olive growers to undertake cultural practices including pest control measures in years with low yield because not enough revenue may be realized to pay for the cost of intervention for that year.

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[17] Olive cake is the solid phase that remains after pressing olives, which contains 3-5% olive oil by mass. Oil from this cake can be used for technical and industrial purposes such as soaps, or other detergents.

Generally speaking, olive profitability varies from grove to grove or from season to season within the same grove. As with any enterprise, there are some key factors, both physical and financial, which determine the ultimate level of olive crop profitability. Some of these factors are related to olive output, others to the efficiency of utilization of inputs. An examination of olive productivity and cost factors is essential in order to gain a better understanding of the links between technical and economic feasibility of the IPM programs.

In Figure 3.1, a tree diagram is developed to highlight the major factors affecting the net returns from olive production. The value of olive gross output is related to several components including yield, price, oil content index and oil quality. The yield is affected by several factors including olive variety (table olive variety versus oil olive variety), age of trees, biennial bearing, level of cultural practices applied in a given year, intensity of pest infestation, time of harvesting, and other agro-climatic conditions. The planting material and variety structure of olive groves in southern Albania is very diverse. Moreover, groves frequently contain trees of the same variety but with considerable differences in yields, resistance to pests, oil content of fruit and so forth. Aging of olive trees is another problem that greatly affect yields and quality of olive products. Aging of olive trees associated with a decline of productive capacity of traditional olive groves is attributed to several deficiencies related to pruning, preparation of the terrain, and the control of key pests.

Besides price factors that are common for any product, the price of the oil olives depends on: oil content, the intrinsic quality of the oil of the area, and the quality of the oil itself in a particular year. Factors related to pest outbreaks and/or diseases (olive fruit fly, olive moth, and black scale) have a considerable negative impact on quality of olive oil. The timing and method of harvesting, fruit storage, and the technique of oil extraction also affect quality. Time of harvesting influences quality of oil as well as the following year's yield. When the fruit remain on the tree for a long time, they appear to inhibit flowering. If the olive is intended for table use, its price depends on the variety, the percentage of ripe fruits, the amount of bruised or defective fruits, fruit size, and so forth.

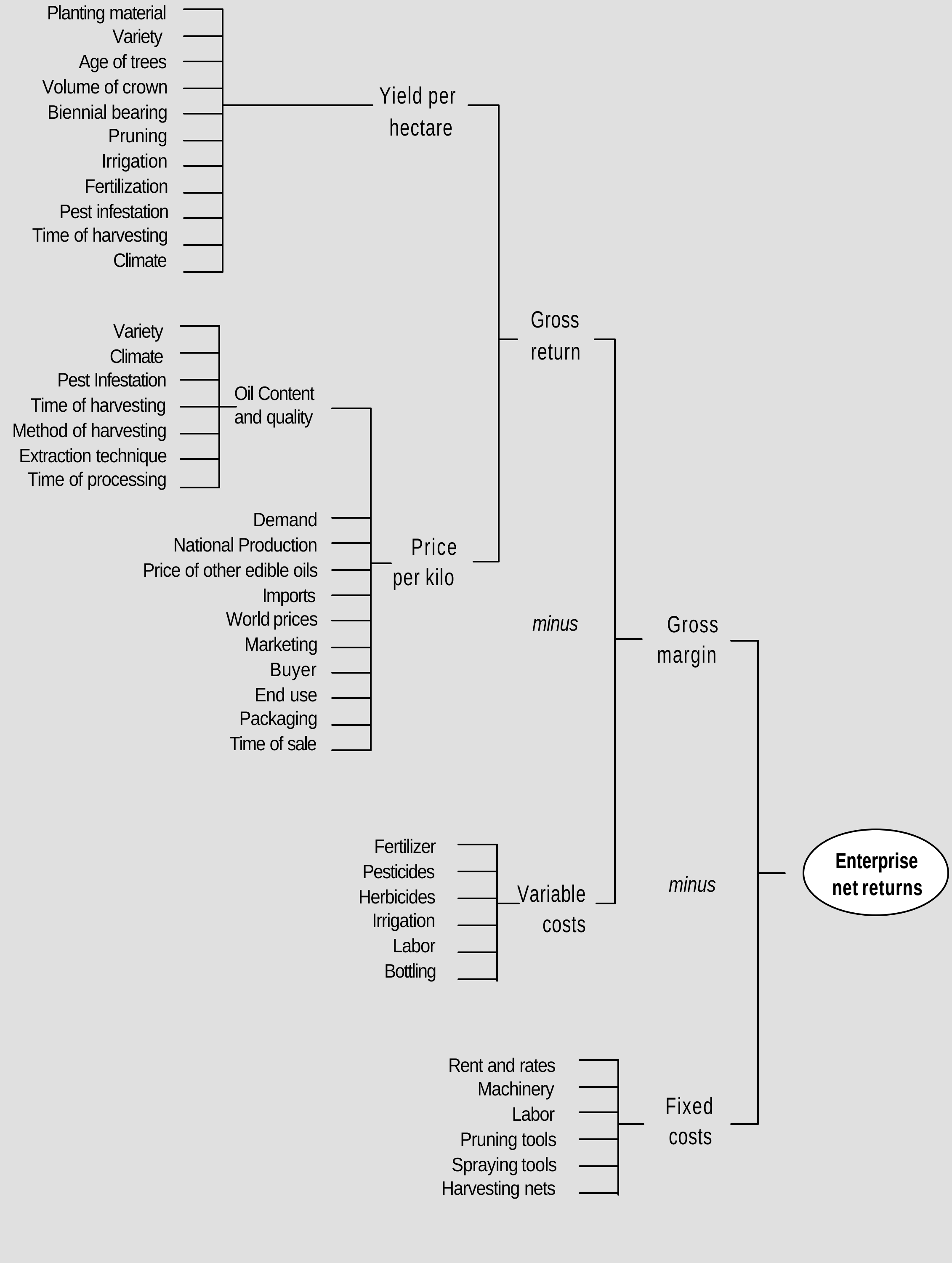

Figure 3.1 Factors affecting the profitability of olive production

The variable costs, of which labor is the largest, vary widely with conditions of olive groves (traditional versus intensive); fragmentation; topography; availability of labor; ecological situation; and so forth. Traditional olive cultivation requires low capital investment and makes little use of mechanization, but it is very labor-intensive. The cost of labor in traditional groves ranges between 47 and 77% of marketable production (Katsoyannos, 1992). Pruning and harvesting are the operations that require the highest input of labor. Irrigation, one of the key operations in the intensive olive groves, results in an increase in yields as much as 300 percent. Mechanized harvesting and pruning can reduce these costs up to 50%. High production costs can be substantially offset by reducing losses caused by pests, which can range from 10 to 50% of yields. Pest control costs do not constitute a large part of olive variable cost. It has been shown that the rate of expenditure for pest treatment in Mediterranean countries varies between 6 and 15% of the total variable costs (Katsoyannos, 1992). However, the introduction of IPM can reduce the pesticide costs.

3.3.2 Net Return Analysis

The major effect olive pests have on olive production system is the decrease in the efficiency with which inputs are converted into outputs (productivity). This decrease in olive productivity may be caused in three ways: (i) by decreasing the value of output for a given level of inputs; (ii) by requiring a higher level of inputs to achieve a given level of output; or (iii) both.

Introduction of IPM as an alternative strategy for controlling olive pests is associated with partial changes in some of the practices related to olive production system. IPM adoption can reduce pesticide costs without affecting revenues and therefore improve profitability. For example, the implementation of IPM practices will reduce some items of variable costs related to pesticides, pesticide application labor, and spraying equipment. IPM can reduce both costs and revenues, and its profitability will depend on the relative reduction of each. Other elements such as expenses for pest monitoring may increase. In some cases the alternatives to pesticides (e.g. pheromones) may actually be more expensive than the pesticides themselves. These partial changes in some of pest control practices are reflected in the measures of costs and returns. Additionally, in the process of diffusion and adoption of IPM as with other technology innovations, not all groups of olive growers are expected to reap the benefits of IPM at the same magnitude. Indeed, as it has been observed in cotton IPM, the marginal benefits have declined as more and more cotton growers have adopted IPM technologies (Arneson and Losey, 1997).

Basically, when evaluating the potential impacts on net revenue associated with the change in farming practices, the whole farm, enterprise, or partial budgets can be used. A whole-farm budget is used when the proposed change involves the reorganization of the entire farm business. When the proposed practice affects only various parts of a crop production system, as is the case with the introduction of olive IPM, then enterprise and partial budgets are used separately or in a combined way to assess the impacts of such proposed change.

To obtain the overall changes in net revenue associated with changes in practices due to olive IPM, this study uses a combination of complete and partial budget analysis. Obviously, where well established complete or enterprise budgets for a given crop are available, an extensive discussion of these basic methods of analysis would be unwarranted. However, this is not the case for the olives in Albania. As will be discussed in chapter 4, the enterprise budgets for olive crop in Albania are nonexistent. The use of a partial budgets in the absence of a baseline enterprise budget for the olive crop may affect the quality of analysis. The complete and partial budgets are also the main generators of data for evaluating the aggregate impacts of IPM at national and regional levels. For these reasons, the main components of net return and budget analysis for evaluating olive IPM practices will be discussed in more detail.

Olive enterprise budget

The budgeting analysis consists of developing a per hectare crop enterprise budget for the conventional production practices and for the innovative IPM production system, which captures changes in price and quantities of inputs and outputs resulting from the adoption of IPM methods.

The enterprise budget summarizes enterprise costs and return projections for a single enterprise and it can be used in many management decisions.

Table 3.2 presents the main components of an enterprise budget for olives in Albania. Major subheadings in the budgets are gross returns, variable costs, fixed costs, and total costs. They are defined as follows:

(i) Gross returns are receipts (price times quantity) from production. For the olive trees, receipts may be zero for several years. Because yields, quality standards, and prices are so variable, representative values for each operation must be used.

(ii) Variable costs are resources that vary according to the enterprise chosen (e.g. producing table olives or oil olives) and the scale of those enterprises, such as the number of olive trees per ha. These costs tend to vary with the level of production.

(iii) Fixed costs are resources that do not change in the short run or with the level of production and exists even if no production takes place. Depreciation, insurance, and taxes are examples of fixed costs. Other fixed costs may include land charges, real estate taxes, and an annual charge for the costs of establishing the olive orchard.

Estimating costs and returns for a given enterprise is not an easy task. Budgets provide a means of assessing whether a proposed plan will be viable. The quality of data used in estimating the budgets is a critical factor affecting their relevance. As Bucket (1981, p. 248) put it “anyone can make money on paper but reality must be the keyword”. In the process of generating data needed to develop olive enterprise budgets and estimate changes in costs and returns associated with olive IPM adoption, variations in varieties grown, management levels, environmental conditions and agronomic practices must be accounted for. As mentioned above, no olive enterprise budgets that capture various olive production systems in Albania seem to have been developed in the past. Additionally, statistics on output, inputs, and prices for the Albanian olive sector are rather fragmentary and unreliable. For these reasons, this study

Table 3.2 Estimated costs and returns to produce olives in Vlora, Albania - 2001[1]

	Unit	Quantity	Price	Value	%
GROSS RETURNS					
Olives					
Olive oil					
1. TOTAL GROSS RETURNS					
Variable Costs					
Cultural:					
Mowing middles					
Pruning					
Brush Disposal					
Irrigation					
Fertilizer (N: 46-0-0)					
Insecticides					
Herbicides					
Miscellaneous					
Subtotal cultural					
Harvest costs:					
Hand pick fruit					
Trucking					
Hired machinery					
Storage					
Miscellaneous					
Subtotal harvest					
Processing costs:					
Trucking					
Press & process					
Bottling					
Labor					
Subtotal processing					
2. TOTAL VARIABLE COSTS					
3. NET RETURNS ABOVE VARIABLE COSTS (1-2)					
Fixed Costs					
Tractor/machinery					
Property taxes					
Land rent					
Buildings					
Olive tree rent					
Pruning tools					
Spraying tools					
Harvesting tools					
Irrigation system					
Interests					
4. TOTAL FIXED COSTS					
5. TOTAL COSTS (2+4)					
6. NET RETURNS ABOVE TOTAL COSTS (1-5)					

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[1] In most olive growing countries, cost and returns are calculated per hectare of olive trees. In Albania this procedure may prove difficult to apply due to severe fragmentation of olive trees following the privatization process in 1991. Also, almost all statistics on olive sector in Albania are reported per olive tree and not per hectare. Therefore, the estimated costs and returns will be calculated per tree.

applies a triangulation approach for obtaining data needed to generate the olive budgets[18]. Specifically, the data are collected from the following sources[19]: (i) the baseline survey of olive growers conducted in the study area where the IPM CRSP research takes place; farmers are asked questions about the cultural practices and input levels they apply in their own olive groves; (ii) on-farm trials related to olive IPM practices conducted in the study area by IPM CRSP research team; and (iii) the opinions elicited from olive experts and extension specialists to identify those practices that may be affected by olive IPM adoption.

Partial Budget

IPM implementation does not involve a complete reorganization of the olive production system. There are many practices related to olive production that remain the same and therefore need not be considered when analyzing the potential consequences of applying IPM. Where baseline enterprise budgets for a given crop are present, the partial budgets are the most practical tool for assessing farm level IPM impacts. The partial budget is designed to show not profit or loss for the crop, but the net increase or decrease in net farm income resulting from the proposed changes in the production system of the crop. As Headley (1983) indicates use of partial budgeting in economic assessment of IPM practices can provide the following useful information to farmers: (i) extent to which new practices increase costs; (ii) how much benefits can be expected to increase; (iii) if the size of operation affects unit costs, (iv) how benefits and costs behave for varying levels of pest damage; and (v) how the price received for the crop affects the feasibility of the recommended practices.

Partial budgets are developed for each IPM practice or combination of practices that is being assessed. It involves identifying those cost and revenue items that will change with the introduction of alternative olive IPM practices and the amount of change. Main elements of the partial budget for olives are the following:

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[18] Triangulation is a term used in rural appraisal and refers to the procedure of finding out information from a variety of sources and methods.

[19] For more details see Chapter 4

A. Added income:

- (i) Added revenue – expected increase in farm revenue from olive products sold due to IPM implementation;
- (ii) Reduced costs – estimated annual expenses that will be eliminated or decreased if the IPM practices are introduced;

B. Added costs:

- (i) Added costs – estimated new expenses and increase in current expenses associated with the new practices; and
- (ii) Reduced revenue – expected value of revenue that will no longer be received if the new IPM practices are applied.

C. Net income increase = A - B

It is important to note that the enterprise and partial budgets are not mutually exclusive tools in terms of estimating the effects of IPM practices on olive net revenue. The former is a source of data for the latter. The term “partial” in case of partial budget does not imply less attention to detail as compared to enterprise budgeting. Their major difference lies to their role in estimating the potential impacts of a proposed change in farming practices. While the enterprise budget provides all physical input requirements with accompanying outputs and respective prices for one unit of production, the partial budget is a practical application of marginal analysis.

Assessing profitability of olive IPM practices

The estimated changes in cost and returns obtained from budget analysis can be used to assess the profitability of IPM practices developed for olive growers. A more formal presentation of this assessment can be applied using as a dependent or response variable, the level of net return (NR) for each IPM practice under consideration.

To begin with, let TR_{CPC} and TC_{CPC} be total revenue and total cost respectively for the olive production system with conventional pest control practices, TR_{IPM} and TC_{IPM} be total revenue and total cost respectively for the olive production system with IPM, NR_{CPC} be net revenue with conventional pest control practices = TR_{CPC} - TC_{CPC}, NR_{IPM} be net revenue with IPM, TR_{IPM} -TC_{IPM}. Assuming that olive growers' objective is profit maximization and given the optimizing conditions according to which the profit is maximized where the marginal cost (MC) is equal to the marginal revenue (MVP), an IPM practice is economically justified if:

$$NR_{IPM} > NR_{CPC} \tag{3.1}$$

that is, when:

$$TR_{IPM} - TC_{IPM} > TR_{CPC} - TC_{CPC} \tag{3.2}$$

Rearranging terms (3.2) can be expressed as:

$$TR_{IPM} - TR_{CPC} > TC_{IPM} - TC_{CPC} \tag{3.3}$$

The expression 3.3 applies for the case when only two alternatives, new and old technology, are considered. In the case where there are more than two alternatives, say *m* alternatives, then, the olive grower's objective to maximize the profit is given as:

$$\text{Max}\ (NR_0, NR_1, NR_2\ \ldots, NR_m) \tag{3.4}$$

where NR_i is net return corresponding to olive production system with the i-th alternative technology or practice, for i=(1…m).

In practice, it is more convenient to evaluate the farm-level costs and benefits of a particular IPM practice using results from the partial budget analysis rather than the results from a complete budget. Define the partial cost (C_{IPM}) as the estimated new expenses and increase in current expenses associated with the introduction of IPM practices:

$$C_{IPM} = TC_{IPM} - TC_{CPC} \tag{3.5}$$

Note that C_{IPM} includes not only the direct cost of the new IPM practice, such as the cost of pesticides or pheromones plus associated application labor cost, but also other additional cost related to handling the increased olive output, if any. Similarly, partial revenue (R_{IPM}) is defined as expected increase in olive revenue due to IPM:

$$R_{IPM} = TR_{CPM} - TR_{CPC} \qquad (3.6)$$

or

$$R_{IPM} = P\,[Q_{IPM} - Q_{CPC}] \qquad (3.7)$$

where P = received price of olive products, Q_{IPM} and Q_{CPC} = olive production with IPM practices and conventional practices respectively.

When the introduction of IPM practices affects yield as well as the quality of the product, the price of olive products with IPM may be different from the price with conventional pest control practices. Therefore, the above framework needs to be adjusted to account for changes in product quality. Indeed, this is the case for better control of some of the olive pests. For example, olive fruit fly, an insect that feeds on olive fruit, affects both quantity and quality of output. It has been shown that olive acidity increases considerably due to fruit infestation by this pest. This change in olive quality is associated with changes in the price of olive products farmers receive. Thus, the partial revenue with IPM (R_{IPM}) is modified to account for the prices of different classes of quality of table olives and olive oil:

$$R_{IPM} = P_{C(IPM)}\,Y_{C(IPM)} - P_{C(CPC)}\,Y_{C(CPC)} \qquad (3.8)$$

Where $P_{C(IPM)}$ and $Y_{C(IPM)}$= price and quantity of olive products with IPM for different classes of quality (c), c=(1, 2, ...n); and n = the total number of quality classes. The expression in (3.8) may be disaggregated further for olive products as follows:

$$R_{IPM} = \sum_{C=1}^{n}\left(P^{to}_{C(IPM)}Y^{to}_{C(IPM)} + P^{oil}_{C(IPM)}Y^{oil}_{C(IPM)}\right) - \sum_{C=1}^{n}\left(P^{to}_{C(CPC)}Y^{to}_{C(CPC)} + P^{oil}_{C(CPC)}Y^{oil}_{C(CPC)}\right)$$

(3.9)

where subscripts *to* and *oil* refer to table olives and olive oil respectively.

Once the partial cost and revenue with IPM (as defined above) are obtained, then their difference, the net returns with IPM given by (3.10)

$$NR_{IPM} = R_{IPM} - C_{IPM} \qquad (3.10)$$

must be greater than zero to conclude that the IPM practices are economically feasible and therefore must be incorporated into olive production system.

3.3.3 Sensitivity Analysis

One of the shortcomings of enterprise and partial budget analysis is that these budgets are based on expected values of prices and output, not accounting for risk and uncertainty. One way to overcome this problem is by performing sensitivity analysis to see how changes in yields, prices and other factors affect the economic viability of the olive IPM program. Once the potential farm level impacts of olive IPM practices are derived, it is of interest to know the maximum acceptable level of an item of olive cost given an estimated level of benefit, or the minimum acceptance level of an item of benefit given an estimated level of cost. Such analysis is useful if some variation can be expected in the level of yield and/or output and input prices.

3.4 Market-level Economic Impacts

The adoption of IPM practices by a large number of olive growers is associated with cost reductions and changes in supply and product quality. These IPM research induced effects can influence olive product prices through a shift in commodity supply and/or demand. The shift in aggregate supply lowers the price of the commodity, which increases the real income of consumers of the commodity and some resource owners. The shift in supply also implies a release of resources required in the initial production of the commodity. The change in commodity prices leads to potential aggregate research benefits as well as distributional effects on producers and consumers. The market-level effects involve a dynamic relationship between today's IPM research investment and future production, consumption, and prices.

Aggregate IPM analysis evaluates the stream of welfare impacts of IPM programs on olive growers, consumers and the country as a whole. This study uses economic surplus analysis to measure IPM research benefits in terms of changes to consumer, producer, and total net economic surplus. Discounted annual net benefits are then compared with the discounted annual costs of IPM research using cost benefit analysis. This section proceeds with a brief discussion of basic economic surplus models and some conceptual issues related to the factors affecting the size and distribution of research-induced market effects. Next, a closed-market economic surplus model under alternative specifications of supply, demand and zone-specific conditions is developed to measure the economic benefits from IPM research-induced gains in olive output and quality improvement. The focus is on considering the simultaneous olive supply and demand shifts due to these improvements. Special attention is given to spatial, uncertainty, and long-run aspects of potential benefits. Finally, it highlights the major assumptions underlying the model specifications.

3.4.1 The basic economic surplus model

Measuring research-induced changes of consumer and producer surplus in terms of a shift in commodity supply and demand is subject to theoretical and empirical difficulties. One is related to the adequacy of welfare measures. Others refer to the determinants of the size and distribution of research-induced economic benefits and costs and the respective assumptions that need to be made regarding: (i) functional forms for supply and demand functions; (ii) the nature of research-induced shift of supply and demand curves; (iii) elasticities of demand and supply; (iv) dynamics of the stream of benefits and costs; (v) trade issues and regional spillover effects; and (vi) uncertainty considerations concerning the potential gains in output and quality improvement, research's success and adoption level.

The measures of consumer and producer surplus

The use of consumer and producer surplus as measures of the change in real income has been the subject of considerable debate by many economists for a very long time (Willing, 1976; Hausman, 1981; Alston, Norton, and Pardey, 1995). Consumer surplus has three key components: a level of utility, a change in price, and a corresponding change in real income. Thus, the theory of consumer surplus relates specifically to measuring the changes in income associated with a change in the price of a good or service with respect to a given level of utility. The literature of welfare economics refers to the following five measures of this change in income: the consumer surplus, compensating variation, equivalent variation, Laspeyres price and Paasche price measures (Mishan, 1976; Hausman, 1981; Salanie, 2000).

Compensating variation is defined as the change in real income associated with a change in price in relation to an initial utility level. Typically, compensating variation is interpreted as a welfare measure of the change in utility. The direct measure of compensating variation is the amount of additional income that would leave the consumer in the initial welfare position if it were possible to buy any quantity of the commodity at the new price. The Laspeyres price price index is defined as the ratio of subsequent price (P_1) to initial price (P_0) multiplied by initial quantity (Q_0), that is:

$$L_{index} = P(P_1, P_0, Q_0) = (P_1 Q_0 \ / P_0 Q_0) \qquad (3.11)$$

This is a measure of the income reduction sufficient to still allow the purchase of initial bundle of goods at the subsequent price of Q. Thus, this is a minimum measure of compensating variation. The Laspeyres price index has an advantage over compensating variation because it is measurable (since its components are observable). However, it underestimates compensating variation.

Equivalent variation is the difference between the initial and subsequent income in relation to subsequent utility level. Its direct measure is the amount of additional income that would leave the consumer in the new welfare position if it were possible to buy any quantity of the commodity at the old price. The

Paasche price index, in turn, is defined as the ratio of subsequent (P_1) to initial price (P_0) multiplied by subsequent quantity (Q_1), that is:

$$P_{index} = P(P_1, P_0, Q_1) = (P_1 Q_1 \ / P_0 Q_1) \qquad (3.12)$$

The Paasche price index is a maximum measure of equivalent variation and leads to an overestimation of equivalent variation. Like the Laspeyres price index, the Paasche price index is measurable as well.

The above four welfare measures are based on using compensated demand function. By contrast, the consumer surplus measure, which is measured off the Marshallian ordinary demand function, is the excess of the price the consumer would be willing to pay over the actual cost of the good. This difference between what the consumer would be willing to pay and what he actually pays is shown by the area under the demand curve and above the market price. Specifically, for an inverse consumer demand function $P_1 = f(Q_1)$ (price as a function of quantity demanded), the consumer surplus for any given equilibrium price (P) and quantity (Q) is defined as (Henderson and Quandt, 1971, p.26):

$$CS = \int_0^{Q^e} P(Q)dQ - p^e Q \qquad (3.13)$$

The major limitation of the economic surplus measure (3.13) is that it overstates the compensating variation and understates equivalent variation for a price decrease. The overestimation of compensating variation is related to the double counting of the change in income resulting from a price decrease (income effect) for a normal good whereas the underestimation of equivalent variation is related to the negative income effect of the change in real income resulting from a change in price for an inferior good. In summary, the following relationship are established between the consumer surplus (CS), the Laspeyres price index (L_{index}), compensating variation (CV), equivalent variation (EV) and the Paasche price index (P_{index}) for a price decrease:

$$L_{index} < CV < CS \qquad (3.14)$$

and

$$CS < EV < P_{index} \qquad (3.15)$$

Producer surplus is a measure of producer welfare and it is analogous to the concept of consumer surplus. It is defined as the difference between what producers are willing and able to supply a good for and the price they actually receive. In other words, producer surplus is the excess of the return to the factor owner above that necessary to induce him/her to provide the factor. The level of producer surplus is shown by the area above the supply curve and below the market price:

$$PS = PQ - \int_{0}^{Q^e} P(Q)\partial Q \qquad (3.16)$$

where P(Q) represents the inverse supply function, P = f(Q). The inverse supply curve, P = f(Q), gives the minimum price (P) that a producer will accept in order to supply a certain level of output (Q). The supply curve of a price-taking firm is the portion of its marginal cost curve that lies above its average variable cost curve. Therefore, the market supply curve may be viewed as a measure of supplier costs, that is, the opportunity costs of supplying various quantities of good. Because a producer's cost is the lowest price he or she will accept, cost is a measure of his or her willingness to sell. The producer surplus measure accounts only for variable costs. However, in the long run, producer surplus equals profit.

The economic rent as defined by Mishan is also closely related to the concept of consumer surplus. Mishan (1976) defines rents as the difference between what the factors, or productive services, of a resource owner earn in their current occupation and the minimum sum he/she is willing to accept to keep [them] there. Rents are therefore the obvious supply side counterpart to consumer surplus. Mishan (1959, p.394) indicates that:

> "...consumer surplus and economic rent are both measures of the change in the individual's welfare when the set of prices facing him are

> changed....Any distinction between them is one of convenience only: consumer surpluses have reference to demand prices, economic rent to supply prices."

In conclusion, it is important to note that although theoretically the economic surplus measures do not correctly take into account the income effect of price changes, the discrepancy between consumer and producer surplus measures and other analogous economic surplus measures discussed above is only a small portion of total benefits. Besides, as Alston et al. (1995) pointed out, this is a minor issue when considering other sources of inaccuracy in technology impact evaluations.

The basic economic surplus model

Alston et al. (1995) presented the basic economic surplus model for evaluating agricultural research. Major assumptions underlying the static, single period model include: linear supply and demand curves, a parallel shift in supply curve due to research, no imports and exports, and perfect competition. Harberger (1971, p. 785) suggested three additional assumptions in order to insure that measures of consumer and producer surplus (discussed above) are consistent with the conventional framework of applied welfare economics. These assumptions are: (i) that the competitive demand price for a given unit measures the value of that unit to consumers; (ii) that the competitive supply price for a given unit measures the value of that unit to producers; and (iii) that consumer and producer net benefits are distributed to the members of each group without regard to whom they accrue.

A graphical description of the basic economic surplus model is given in Figure 3.4 (see subsection 3.4.2 below). The initial linear supply curve is:

$$Q^S = a + bP \qquad (3.17)$$

where Q^S is the initial quantity supplied, a is the initial supply intercept, and b is the fixed supply slope parameter. The initial linear demand curve is:

$$Q^D = g - dP \tag{3.18}$$

where Q^D is the initial quantity demanded, g is the initial demand intercept, and d is the fixed demand slope parameter. The corresponding research induced change in quantity supplied Q^{SR} and quantity demanded Q^{DR} are:

$$Q^{SR} = a + b(P + k) \tag{3.19}$$

$$Q^{DR} = g - dP \tag{3.20}$$

where $k = (P_0 - D)$ is downward supply shift due to research-induced cost saving (see Figure 3.4)

For each period, equilibrium quantities and prices are determined in the "with" and "without" research scenarios through the respective market clearing conditions:

$$\sum_i Q^S = \sum_i Q^D \qquad \text{(without research)} \tag{3.21}$$

$$\sum_i Q^{SR} = \sum_i Q^{SD} \qquad \text{(with research)} \tag{3.22}$$

Solving the demand and supply equation at the pre-innovation and post-innovation equilibrium points given by (3.21) and (3.22) yields equilibrium prices P^e and P^{eR} respectively:

$$P^e = (g - a)/(b + d) \qquad \text{for } k=o \tag{3.23}$$

$$P^{eR} = (g - a - Kb)/(b + d) \qquad \text{for } k=KP_0 \tag{3.24}$$

The research induced price change is:

$$P^e - P^{eR} = Kb/(b + d) \tag{3.25}$$

From (3.25), converting the slopes to elasticities the “with research” equilibrium price P^{eR} is[20]:

$$P^{eR} = P_0\left[1-(ke)/(e+h)\right] \qquad (3.25')$$

Denoting $Z = ke/(e+h)$ defined as the relative reduction in price, ε the supply elasticity and η the absolute value of the price elasticity of demand, the post-innovation equilibrium price and quantity can be written as:

$$P^{eR} = P_0(1-Z) \qquad (3.26)$$

$$Q^{eR} = Q_0(1-hZ) \qquad (3.27)$$

The gains in consumer and producer surplus can be expressed algebraically as follows:

$$\Delta CS = \left(P_0 - P_1^R\right)\left[Q_0 + 0.5\left(Q_1^R - Q_0\right)\right] \qquad (3.28)$$

and the corresponding change in producer surplus is:

$$\Delta PS = \left(k + P_1^R - P_0\right)\left[Q_0 + 0.5\left(Q_1^R - Q_0\right)\right] \qquad (3.29)$$ [21]

Substituting equation (3.26) and (3.27) into (3.28) and (3.29) gives the following formulas for estimating changes in economic surplus:

$$\Delta CS = P_0 Q_0 Z(1 + 0.5Zh) \qquad (3.30)$$

$$\Delta PS = P_0 Q_0 (K - Z)(1 + 0.5Zh) \qquad (3.31)$$

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K(1 + 0.5Zh) \qquad (3.32)$$

---

[20] $K=k/P_0=(P_0-D)/P_0$ is the supply shift relative to the equilibrium price (see Figure 3.4 below)

[21] The expression ($k + P_1^R - P_0$) is equivalent to ($P_1 - D$) in Figure 3.4. (for a proof of this see Alston et al., 1995, p. 211)

The economic surplus model in general and measures of consumer and producer surplus are not without shortcomings (Alston et al., 1995). In addition to the measurement error related to Marshallian concepts of producer and consumer surplus discussed above, the model is criticized: (i) for being a partial equilibrium analysis, ignoring any effects of changes in other product and factor markets in the economy; (ii) for involving implicit value judgments in the process of estimating research benefits and costs; (iii) for ignoring transaction costs that arise due to asset fixity (sunk cost), imperfect information (bounded rationality), and free-riding problem. For example, when transaction costs are not incorporated into the welfare analysis of research impacts, the results overstate the benefits of activities with high transaction costs both absolutely and relatively to activities with relatively low transaction costs. Addressing these major points of criticism, Alston et al. (1995) underscore the need for a more encompassing economic surplus model developed in a general equilibrium framework.

Functional forms of supply and demand

The functional forms commonly used for estimating research benefits are linear and constant elasticity supply and demand curves. In case of linear demand and supply curves, the elasticities change as quantity changes along the curve. For example, the elasticity of supply is known for a single point, at pre-innovation equilibrium point and the slope for the rest of the curve is extrapolated using this fixed value of elasticity. One problem with this assumption is that when supply is inelastic at the pre-innovation equilibrium, the price intercept of the estimated supply function may be below zero, implying that positive quantities would be supplied at negative prices. As a means to avoid this shortcoming of the linearity assumption, several authors used a "kinked" supply curve at the initial equilibrium (Rose, 1980; Norton et al. 1987). However, Alston et al. (1995) pointed out that there is no practical difference to using a linear supply curve with or without a kink because the economic surplus is the same in both cases.

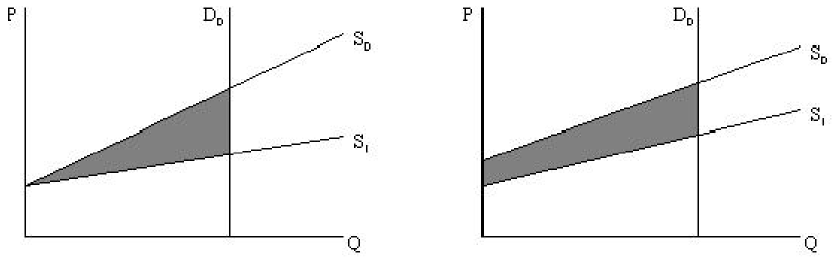
The constant elasticity supply and demand curves have been used as an alternative to the linear function form. The supply function in the constant elasticity model passes through the origin regardless of its elasticity. Although the constant elasticity curves might sound more appealing than the linear ones because they avoid "the possibility of negative price intercept", still the model is questionable in cases when the extrapolation occurs far from the initial equilibrium (Alston et al., 1995). Also it assumes pivotal supply shift.

A third alternative is the use of constant elasticity curves with a positive price intercept (Pachico, Lynam and Jones, 1987). Compared to the first two alternatives, this model has two advantages. First, it is more realistic because the positive price intercept is independent of elasticity assumptions and second, it is flexible with respect to the nature of supply shift (Alston et al., 1995). However, on practical grounds, this model may not be that appealing since it requires a nonlinear algorithm for its solution.

Despite criticism, the linear functional form has been used in most research evaluation studies because the linearity assumption allows the use of simple algebra to calculate measures of consumer and producer surplus. (Alston et al. 1995). In conclusion, neither theory nor econometric practice are helpful in finding the "ideal" functional form to a particular situation. Generally speaking, the best a chosen functional form can provide is a local approximation of the parameter it seeks to estimate. In addition, Alston et al. (1995, p. 63) pointed out that from an empirical point of view measures of research benefits and their distribution are much more sensitive to the nature of research-induced supply shift and the elasticity choices than choices of functional form.

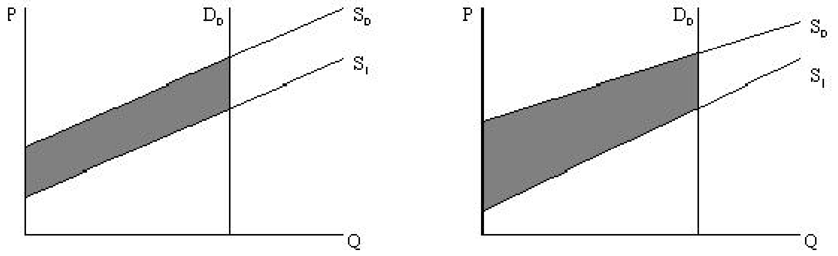
Nature of supply and demand shift

The nature of supply and demand shift is one of the most important determinants of the size and distribution of research benefits. This issue has been subject of controversial debate and discussions among economists and researchers since the early 80's. Lindner and Jarrett (1978), Rose (1980), and Norton and Davis (1981) argued that the use of research evaluation procedures without regard to the type of supply shift can result in substantial bias in estimation of research benefits. As illustrated in Figure 3.2, Lindner and Jarrett (1978) showed that different types of technical change might be associated with various types of supply and demand shift including parallel, divergent (pivotal or proportional), and convergent. Benefits estimated based on these different types of shifts may be overstated or understated depending upon the nature of the actual supply shift. These differences in measures of total research benefits are shown in Figure 3.2 as shaded areas. For example, total benefits from a parallel shift are nearly double those from a pivotal shift of equal size at the pre-innovation equilibrium.



(a) Divergent -pivotal

(b) Divergent -proportional



(c) Parallel

(d) Convergent

Figure 3.2 Types of supply shift (Alston et al., 1995)

Producer's benefits increase in aggregate if for both low-cost producers and high-cost producers the adoption of new technology results in the same absolute reduction in average costs (parallel supply shift). A parallel shift (Figure 3.2c) implies the change in average cost equals the change in marginal cost at every point along the curve. It also implies no change in the elasticity of substituting abundant resources for relatively scarce resources. With a parallel supply shift producers always benefit from research unless supply is perfectly elastic or demand is perfectly inelastic.

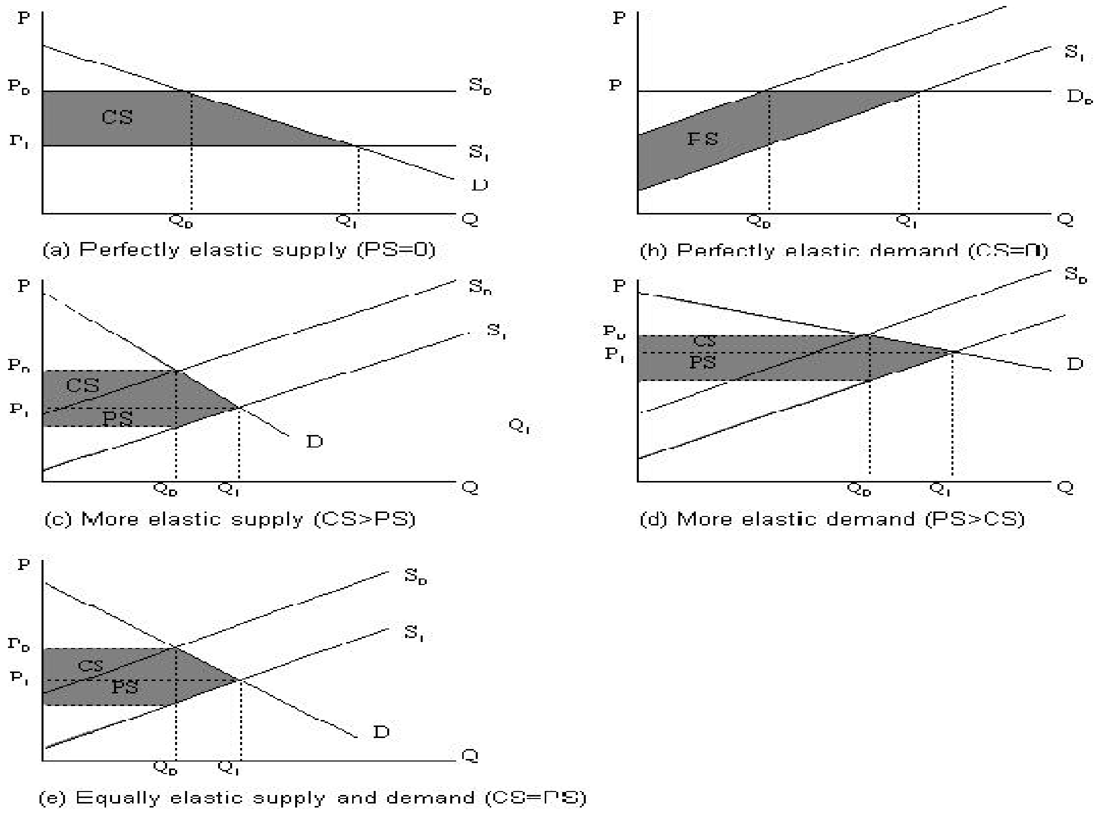
With a divergent supply shift (Figure 3.2a and b) the absolute vertical distance between supply curves increases as quantity supplied increases, implying that absolute reduction in average costs is greater for high-cost producers than for low-cost producers. Thus, low-cost producers at the bottom end of the supply curve will gain less in terms of absolute cost reduction than high-cost producers. With a pivotal supply shift, producers benefit only when demand is elastic; when this is not the case the producers lose. A convergent shift (Figure 3.2d), in turn, implies that absolute reduction in average costs is greater for low-cost producers than for high-cost producers. While a proportional or pivotal shift implies an increase in the elasticity of substitution, a convergent shift results in a decrease in elasticity of substitution.

It is argued that the nature of supply shift depends on the type of innovation and/or the structure of the average cost among producing firms and the location of those firms on the industry supply curve (Alston et al., 1995). Lindner and Jarrett (1978) concluded that biological and chemical innovations in general tend to result in proportional supply shifts while organizational innovations are likely to result in parallel or even convergent supply shift as they may be scale-dependent. IPM, being a knowledge and information-intensive pest management strategy, can be considered an organizational innovation and may result in a parallel shift and be beneficial to growers regardless of demand elasticities.

Clearly, the above discussions indicate that the assumption about the nature of supply or demand shift is unavoidable when measuring size and distribution of research benefits. Whether the shift is parallel, convergent, or divergent, cannot be universally clarified on theoretical grounds. Rose (1980) and Alston et al. (1995) recommended the use of a parallel shift assumption whenever a clear empirical justification for a convergent or divergent shift is lacking.

Elasticities of demand and supply

Assumptions about elasticities of supply and demand have greater effect on the distribution of research benefits to consumers and producers than on the size of total benefits. For linear supply and demand curves, each of the surplus areas can be measured as the sum of a rectangle and a triangle (see Figure 3.3). As far as the total economic surplus is concerned, the elasticity assumption affects the triangle area only. Thus, the more elastic supply and demand is, the larger the triangle and the larger the total welfare benefits.



(a) Perfectly elastic supply (PS=0)

(b) Perfectly elastic demand (CS=0)

(c) More elastic supply (CS>PS)

(d) More elastic demand (PS>CS)

(e) Equally elastic supply and demand (CS=PS)

Figure 3.3 Effects of elasticities on the size and distribution of research benefits

Alston et al. (1995) argued that from an empirical standpoint, the area of triangles is very small compared to the area of rectangles and therefore the total benefits are quite insensitive to elasticities of demand and supply[22]. Thus, elasticity assumptions have much greater affect on the distribution of benefits between producers and consumers than the size of total benefits. For example, in cases of a perfectly elastic supply and a downward-sloping demand (as might be the case of a closed economy) all research benefits go to consumers. No benefits go to producers because research induced change in price is equal to research-induced cost-saving (Figure 3.3a). With a perfectly elastic demand (the case of a small open economy that can not affect the world price of the

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[22] Alston et al. (1995, p.59) show that for commonly used research-induced supply shifts of less than 10 percent of the initial price (*K=0.1*) the triangle would be less than 2.5 percent of the rectangle.

commodity), all benefits go to producers because there is no research-induced change in price (Figure 3.3b). The more (less) elastic the supply is relative to demand, the greater (the smaller) the consumer share of total research benefits is as compared to the producer share (Figure 3.3c and d respectively). Finally, when supply and demand have equal elasticities, the research benefits are shared equally between consumers and producers (Figure 3.3e).

3.4.2 Modeling IPM research impacts in a closed economy

A closed–economy model, where no imports or exports occur, is developed for estimating the size and distribution of economic benefits from olive IPM/CRSP research. The model draws on Unnevehr (1990) and Alston et al. (1995). It accounts for IPM research-induced supply shifts, increased demand owing to quality improvement, and research-induced spillovers to non-target zones. Three separate model specifications arise from the different assumptions made about the potential aggregate effects of IPM research with respect to olive yield gains/cost reduction and quality improvement. The first model specification considers market effects of a shift in supply of olive products due to IPM research-induced gains in olive yields and/or cost reduction. The second model specification accounts for the potential quality improvement of olive IPM research associated with a shift in domestic demand curve of olive products. Finally, a third model specification simultaneously incorporates the gains in olive output and quality improvement resulting from the IPM research as reflected in a rightward shift of supply and demand curves respectively.

Case 1: Economic surplus model with a shift in olive supply

The analytical framework for measuring IPM research benefits for case 1 with a shift in olive supply only where no quality improvement occurs is depicted in Figure 3.4. The market demand for olive products is represented by a conventional downward-sloping demand curve FD. The initial olive supply[23]

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[23] Olive oil is the major olive product of economic importance in the study area (See Chapter 4 and Daku et al., 2000)

using conventional pest control strategies is represented by an upward-sloping supply curve E_0S_0. The initial equilibrium price and quantity are P_0 and Q_0 respectively. Following the adoption of olive IPM strategies, the supply shifts to E_1S_1 resulting in a new price and quantity of P_1 and Q_1. The olive supply shift results in a corresponding price decrease and consumers receive welfare benefits equal to area FBP_1. Thus, the net consumer surplus gain is the area P_0ABP_1.

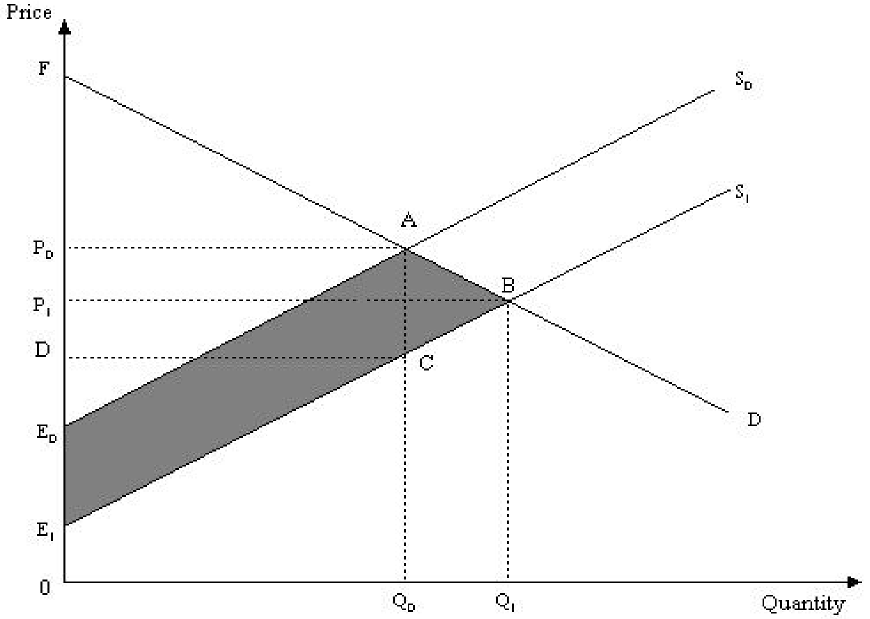

Figure 3.4 Size and Distribution of Economic Surplus due to IPM research-induced shift of olive supply

The impact of the IPM research-induced supply shift on producer surplus is more complex. The original producer surplus is represented by the area P_0AE_0 (the area below the olive price but above the cost of production). After the supply shift, producer surplus becomes the area P_1BE_1. The change in producer surplus is determined by two factors: gains from the unit cost reduction in production and losses from research-induced change in commodity price. Thus, the area P1BCD represents the net producer surplus gain. Producer welfare may either increase or decrease when confronted with a technical innovation, depending on the relative magnitude of the two effects.

However, by aggregating consumer and producer surplus changes, society as a whole unambiguously gains area E_0ABCE_1.

In summary, the changes in consumer (CS), producer (PS), and total economic surplus (TS) due to the IPM research-induced shift in olive supply are:

Surplus measures
without IPM research: $CS_0 = FAP_0$
$PS_0 = P_0AE_0$ (3.33)
$TS_0 = FAE_0$

Surplus measures
with IPM research: $CS_1 = FBP_1$
$PS_1 = P_1BE_1$ (3.34)
$TS_1 = FBE_1$

Changes in
surplus measures: $DCS = P_0ABP_1$
$DPS = P_1BCD$[24] (3.35)
$DTS = E_0ABE_1$

Several formulas have been developed to measure the areas in Figure 3.4 representing consumer, producer and total net economic surpluses. Formulas reflecting the model specifications of linear supply and demand curves, a parallel shift of supply curve, and a vertical or cost decreasing in the supply curve are shown below (Alston et al., 1995).

Let ΔCS be change in consumer surplus, ΔPS be change in producer surplus, ΔTS be change in total net economic surplus, K be the proportional vertical shift in supply curve, AC/AQ_0 or $(P_0 - D)/P_0$, due to a cost reduction, ε be the supply elasticity, η be the absolute value of the demand elasticity, P_0 and Q_0 be equilibrium olive price and quantity without IPM research (before supply shift), P_1 and Q_1 be equilibrium price and quantity with IPM research, and $Z = -(P_1-P_0)/P_0 = K\varepsilon/(\varepsilon + \eta)$ be the relative reduction in price. The changes in economic surplus are calculated as:

$$\Delta CS = P_0Q_0Z(1+0.5Zh) \tag{3.36}$$

$$\Delta PS = P_0Q_0(K-Z)(1+0.5Zh) \tag{3.37}$$

$$\Delta TS = P_0Q_0K(1+0.5Zh) \tag{3.38}$$

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[24] (area P_0AE_0 = area DCE_1)

Since this study seeks to estimate the zone specific measures of economic surplus with and without IPM research, the changes in economic surplus due to IPM research can be computed using a different set of formulas that is closely related to (3.36-3.38). The change in producer surplus in zone *i* at time *t* is computed as:

$$\Delta CS_{it} = \left(P_{it} - P_{it}^{IPM}\right)\left[Q_{it} + 0.5\left(Q_{it}^{IPM} - Q_{it}\right)\right] \tag{3.39}$$

and the corresponding change in producer surplus is:

$$\Delta PS_{it} = \left(K_{it} + P_{it}^{IPM} - P_{it}\right)\left[Q_{it} + 0.5\left(Q_{it}^{IPM} - Q_{it}\right)\right]^{25} \tag{3.40}$$

where the first subscript, *i*, refers to a zone or a region and the second subscript, *t*, refers to years from the initial starting point of the evaluation, P_{it}^{IPM}, P_{it} and Q_{it}^{IPM}, Q_{it} are olive price and quantity respectively "with" and "without" olive IPM research.

Case 2: Economic surplus model with a shift in olive demand

Often, research-induced technical change is associated with changes in product quality. Products with varying quality characteristics face differential demands. The higher the quality of goods the larger the premium they receive. Quality-enhancing research presumably shifts the product demand curve upward given the fact that consumers will demand more of the product at each price if it contains a higher proportion of a relatively higher priced characteristics (Voon and Edwards, 1991). There are two major approaches to assessing the welfare impacts from quality-improving research (Alston et al., 1995). One approach is the use of multiproduct models in which (i) either product characteristics are treated as products (quality as continuous variable), or (ii) different qualities of products are treated as different products (discrete variation in quality). On practical grounds, the use of multiproduct modelling

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[25] The expression ($K_{it} + P_{it}^{IPM} - P_{it}$) is equivalent to ($P_1 - D$) in Figure 3.4.

approach is complicated because it is difficult to measure the substitution effects between the different qualities of a particular product as well as the substitution effects in production. The other approach, commonly used in impact evaluation studies, treats research-induced quality change as a demand shift. In this approach, different qualities of the product are considered as perfect substitutes in consumption and product substitution in response to price changes is ruled out. This study employs the second approach.

While the evaluation of welfare effects from research-induced supply shift has received considerable attention, this has not been the case for the assessment of research returns to quality improvement (Voon and Edwards, 1992; Alston et al. 1995). To date, no study has been carried out that assess the market impacts of the quality-improving potential of IPM research. However, in other areas of agricultural research some studies do exist. For example, Unnevehr (1986) estimated research gains from rice quality improvements in southeast Asia. Lemieux and Wohlgenant (1989) evaluated the welfare changes from a rise in meat yield and in meat quality from the use of a growth hormone on pigs in the U.S. Voon and Edwards (1991, 1992) estimated the size and distribution of research benefits from a reduction of backfat depth in pigs in Australia and from research that increases protein content in Australian wheat. Except for the study carried out by Lemieux and Wohlgenant, no other widely available published study has considered the estimation of the research-induced changes in net economic benefits by examining simultaneous shifts in supply and demand curves.

In this study, it is assumed that IPM research on olives leads to a quality improvement of olive products, especially olive oil[26]. An IPM research-induced reduction in olive oil acidity and in pesticide residues, among other factors, improves characteristics of olive products and eventually increases demand for high valued products. For example, consumers will pay much more for extra virgin olive oil with low level of acidity produced under an IPM production system. Application of olive IPM strategies increases the value of characteristics for olive products as well as the price of such products.

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[26] See section 1.2 of the first chapter.

Ladd and Suvannunt (1976) and Unnevehr (1990) have shown theoretically that quality-improving innovations change the amount of commodity consumed and therefore lead to a rightward shift in the commodity demand curve. In their model of consumer demand for good characteristics, Ladd and Suvannunt (1976) view consumer demand such that consumers derive utility or satisfaction from the characteristics that goods possess, rather than the goods themselves. The market price P_i for product i with m classes of quality is expressed as:

$$P_i = \sum_{j=1}^{m} X_{ij} P_{ij} \tag{3.41}$$

where $j=(1.2....m)$ denotes classes of product quality, X_{ij} is the amount of the j-th characteristic provided by one unit of product i, and P_{ij} is the marginal implicit price for the j-th characteristic of product i. The expression (3.41) shows that the product price paid by the consumer equals the sums of marginal values of the product's characteristics.

The increase in quantity demanded arising from research-induced improvement in product quality is equivalent to an increase in consumer utility obtained from each unit of that product with improved characteristics. From equation (3.41) this increase is equal to:

$$g = \left(X_{ij}^{'} - X_{ij}\right) P_{ij} \tag{3.42}$$

where g is the economic gain per unit of product i consumed, P_{ij} is the implicit price of characteristic j, $X_{ij}^{'}$ is the research-induced new value of characteristic j obtained from one unit of product i, and X_{ij} is the old value of product characteristic j. If more than one characteristic of the product changes due to research, then the shift in demand is expressed as:

$$g = \sum_{j=1}^{m} \left(X_{ij}^{'} - X_{ij}\right) P_{ij} \tag{3.43}$$

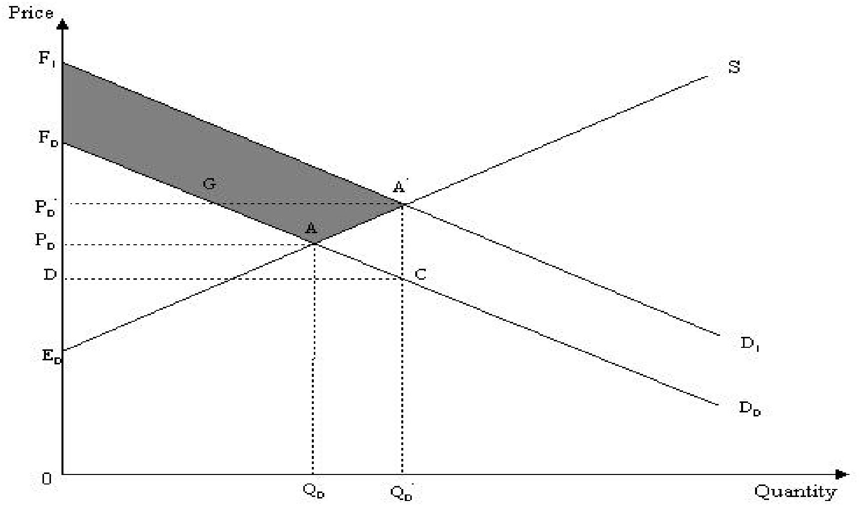

Figure 3.5 Size and distribution of olive IPM research benefits due to quality improvement

Figure 3.5 depicts the case of a demand shift from IPM research-induced improvements in olive product quality but with no shift in the supply curve[27]. Quality improvement in olive products causes an upward shift in demand schedule from F_0D_0 to F_1D_1. The equilibrium output price and quantity increase from P_0 to P_0' and Q_0 to Q_0' respectively. The vertical shift in demand is represented by $A'C$. This is equivalent to measure *g* (economic gain per unit of product) as described by equation (3.41).

Changes in consumer, producer, and total net economic surplus due to quality improvement are:

$$\Delta CS = F_1A'GF_0 - P_0'GAP_0 \qquad (3.44)$$

$$\Delta PS = P_0'GAP_0 + GA'A \qquad (3.45)$$

$$\Delta_D TS = F_1A'AF_0 \qquad (3.46)$$

Thus, consumers gain the area $F_1A'GF_0$ but loose the area $P_0'GAP_0$. Producers gain the area $P_0'A'AP_0$[28] and society's net gain is the shaded area $F_1A'AF_0$. Formulas for calculating changes in net economic benefits due to quality improvement are:

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[27] Olive supply is assumed to be less than perfectly elastic.

[28] Of which $P_0'GAP_0$ is a transfer from consumers.

$$\Delta CS = P_0 Q_0 (G - Z)(1 + 0.5Ze) \qquad (3.47)$$

$$\Delta PS = P_0 Q_0 Z(1 + 0.5Ze) \qquad (3.48)$$

$$\Delta TS = P_0 Q_0 G(1 + 0.5Ze) \qquad (3.49)$$

where $G = g / P_0 = (P_0^{'} - D) / P_0$ is the proportional vertical shift in the demand curve due to quality improvement and $Z = Gh/(\varepsilon + h)$ *is* the relative increase in price.

Case 3: Economic surplus model with a simultaneous shift in olive supply and demand

Figure 3.6 depicts the economic surplus model with a research-induced rightward shift in olive supply and demand for the closed economy case. Point $A^{'}$ in Figure 3.6 represents the equilibrium price $P_0^{'}$ and quantity $Q_0^{'}$ that would have existed due to a shift in demand only with no supply shift. This situation is equivalent to the economic surplus model described in case 2 (Figure 3.5). After supply shift, the new equilibrium moves to point $B^{'}$ with price $P_1^{'}$ and quantity $Q_1^{'}$ (Figure 3.6). The consumers gain the area represented by area $P_0^{'} A^{'} B^{'} P_1^{'}$, producers gain area $P_1^{'} B^{'} C^{'} D^{'}$, and the net economic surplus is represented by area $P_0^{'} A^{'} B^{'} C^{'} D^{'}$ that is equivalent to the area $E_1 E_0 A^{'} B^{'}$. Thus, changes in economic surplus measures are:

$$\begin{aligned} \Delta CS &= P_0^{'} A^{'} B^{'} P_1^{'} \\ \Delta PS &= P_1^{'} B^{'} C^{'} D^{'} \\ \Delta_{(S/D)} TS &= P_0^{'} A^{'} B^{'} C^{'} D^{'} \equiv E_1 E_0 A^{'} B^{'} \end{aligned} \qquad (3.50)$$

Summarizing results from the second and third model specifications, the total net economic surplus due to a simultaneous shift in olive demand and supply is:

$$\Delta TS = \Delta_D TS + \Delta_{(S/D)} TS = F_1 A^{'} A F_0 + E_1 E_0 A^{'} B^{'} = F_1 A^{'} B^{'} E_1 E_0 A F_0 \quad (3.50^{'})$$

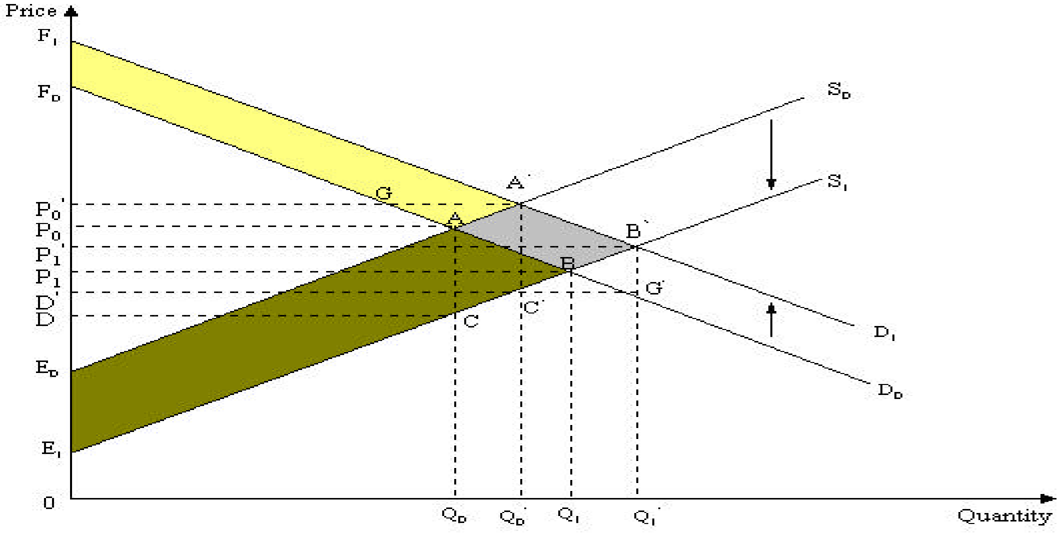

Figure 3.6 Size and distribution of economic surplus due to IPM research-induced change in olive product yield and quality.

Assuming the horizontal shift in supply is larger than horizontal shift in demand, the new equilibrium price and quantity at point B' are greater than with IPM research-induced shift in supply only (Case 1), but price is less and quantity greater than the case with a shift in demand only (Case 2). Apparently, when a technology innovation involves simultaneous rightward shifts in supply and demand, the net effect is for quantity to increase more and price to fall less than the case when IPM research induces a shift in supply only.

Following Norton et al. (1987) formulas for computing changes in net economic benefits of an IPM research-induced rightward shift in supply after the demand shift takes place are[29]:

$$\Delta CS = P_0^{'} Q_0^{'} Z(1+0.5Zh) \tag{3.51}$$

$$\Delta PS = P_0^{'} Q_0^{'} (K-Z)(1+0.5Zh) \tag{3.52}$$

$$\Delta TS = P_0^{'} Q_0^{'} K(1+0.5Zh) \tag{3.53}$$

Unlike the model in case 1, the estimation of potential changes in measures of economic benefits using formulas (3.51 – 3.53) requires calculating the price

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[29] Norton et al. (1987) estimated the effects of an exogenous shift in demand due to population and income growth.

and quantity that would have existed with a demand shift but without a supply shift. The "after demand shift" equilibrium price and quantity (referring to equilibrium at point A' in Figure 3.6) are computed following the same procedures describe in section 3.4.1 when the basic economic surplus was presented. The equilibrium price is[30]

$$P_0^{'} = P_0 \left[1 + \frac{\frac{g}{Q_0}}{(e+h)} \right] \qquad (3.54)$$

and the equilibrium quantity

$$Q_0^{'} = Q_0 + g - \frac{gh}{(e+h)} \qquad (3.55)$$

where G is the research-induced vertical shift in demand (expressed as a price change equal to the vertical distance B'G' or $(P_1^{'} - D^{'})$ in Figure 3.6).

3.4.3 Major assumptions of the model

Any model is based on simplifying assumptions in order to be realistic for the problem it is addressing. The assumptions underlying the above model specifications include:

(i) *Perfect competition* – olive product prices are determined through interaction of demand and supply forces in a perfectly competitive market; producers and consumers have perfect knowledge and information regarding good markets and the quality characteristics of olive products (the model ignores the question as to whether consumers have identical preferences and tastes for olive product quality and if these preferences and tastes change over time); and olive growers produce homogenous olive products.

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[30] Computations for deriving formulas 3.54-3.55 appear in appendix B.

(ii) *Closed economy* - international trade is not incorporated in the model. The closed economy assumption was made for several reasons. The IPM research-induced welfare effects are expected to be limited to the domestic olive market because the definition of quality standard for olive products differs between the Albanian and world markets. The table olives and olive oil produced in Albania presently do not meet the quality standards set by the European Union and other importing nations. Therefore, the country's olive oil may be considered a different product from that of other nations in terms of quality standards. Additionally, the existing domestic marketing channels are unable even to insure the flow of olive products for sale from olive growing regions to other regions within the country, let alone to facilitate exports of country's olive products. In fact, no set of quality standards are established yet in Albania and it is unlikely, at least in the near future, that olive growers will get any premium price from increased quality of olive products. Another reason is that at present, foreign trade in olive products is negligible in Albania. Imports of olive products are almost nonexistent and exports very small. Presently, the domestic olive oil price is below the world price. Therefore, the low domestic price and the high transport costs inhibit imports of olive oil. Finally, the volume of export-imports for olive products in Albania is not likely to increase in the future because from now on Albanian's olive growers will have to compete with the highly subsidized olive sector of European Union member countries (Economist, 2001).

(iii) *Supply and demand curves* - for each case, linear demand and supply curves as well as a parallel shift in demand and supply is assumed. The slopes of supply and demand curves are assumed to be constant for each zone for all time periods. The changes in supply or demand for olive products due to factors other than IPM research such as population and/or income growth are ignored[31].

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[31] The statistics show that recently Albanian population has experienced a sharp decline due to a wave of migration to other countries.

(iv) *Local spillover effects* – it is assumed that there will be spillover effects of olive IPM research from the research target zone to other agro-ecological olive growing zones in Albania. These spillover effects are related to technology transfer from research target zone to other zones that can be adopted without any adaptive research in those non-target zones. Except for price elasticities of demand and supply, discount rate, and the expected increase in price due to quality improvement that are assumed the same for all zones, other components of the model such as adoption, yield gains and so forth are elicited separately for each olive growing zone.

In addition, there are a number of assumptions that need to be made with regard to adoption profiles, distribution of expected net yield gains, demand and supply elasticities and so forth. These procedures and their corresponding assumptions appear in chapter 4.

3.4.4 Evaluation of stream of IPM research benefits and costs

Once the IPM research-induced changes in economic surplus measures are obtained, the next step is to aggregate those measures into summary measures of research benefits such as the net present value (NPV), the internal rate of return (IRR) and benefit-cost ratio (B/C). From the literature on capital budgeting, the NPV of a program of research undertaken in time *t* is calculated as the sum of the stream of future benefits (change in economic surplus), B_t, minus the costs, C_t, associated with the IPM program, discounted at an appropriate rate, r:

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \qquad (3.56)$$

If the NPV is negative for a given research project, then undertaking that project is not worthwhile, while a positive NPV indicates that the research project is profitable. The NPV is not always an accurate measure of ranking because it does not take into account the scale of the investment for each project. Therefore, Alston et al. (1995, p. 33) proposed to express the NPV per unit of research investment or scientist and rank programs accordingly.

The IRR is the discount rate at which the NPV is exactly zero. In other words, the IRR is the interest rate that will make the implementation of the research program break even. This is analogous to solving for *r* in:

$$0=\sum_{t=0}^{T}\frac{B_t-C_t}{(1+r)^t} \tag{3.57}$$

If the IRR exceeds the minimum acceptable discount rate or the opportunity cost of funds, the project is worth further consideration. The B/C ratio is computed as:

$$B/C \quad ratio=\sum_{t=0}^{T}\frac{B_t}{(1+r)^t}\Bigg/\sum_{t=0}^{T}\frac{C_t}{(1+r)^t} \tag{3.58}$$

Basically, the NPV per scientist or per unit of investment is used in ex-ante evaluation studies. For a given scenario, the computed measures of benefits for each zone in each time period are: DCS_{it}, DPS_{it}, DTS_{it}. Using a planning horizon of thirty years and a discount rate of 6%, the present values of IPM research benefits are defined as[32]:

$$VCS_t=\sum_{t=0}^{30}\Delta CS_{it}^{tz}\Big/(1+r)^t+\sum_{t=0}^{30}\Delta CS_{it}^{sp}\Big/(1+r)^t \tag{3.59}$$

$$VPS_t=\sum_{t=0}^{30}\Delta PS_{it}^{tz}\Big/(1+r)^t+\sum_{t=0}^{30}\Delta PS_{it}^{sp}\Big/(1+r)^t \tag{3.60}$$

$$VTS_t=\sum_{t=0}^{30}\Delta TS_{it}^{tz}\Big/(1+r)^t+\sum_{t=0}^{30}\Delta TS_{it}^{sp}\Big/(1+r)^t \tag{3.61}$$

where the subscript, *tz,* refers to the research target zone and the subscript, *sp*, refers to research spillovers from non-target olive growing zones.

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[32] For more details on choosing discount rate in this study see section 4.6 in the next chapter.

3.5 Modeling Prospects for Olive IPM Adoption

3.5.1 The process of IPM adoption

Figure 3.7 depicts the decision-making process of IPM adoption in light of Roger's model of diffusion of innovation (Rogers, 1995). According to Rogers's model, first the farmer becomes aware of innovation, seeks to gain knowledge and extend information on proposed innovative technology, and forms an opinion about it. Next, the farmer decides to conduct trials of the technology on a limited basis and if, based on the results of the trials, the farmer favors adoption, implementation follows.

Referring to Figure 3.7, the farmer becomes aware of the pest problem when a certain pest causes crop damage and consequently prevents the farmer from meeting his family needs and objectives[33]. Needs and objectives, in turn, are influenced by a set of economic, social, psychological and technical factors. Farmer perceptions, attitudes, and knowledge of pest problems affect the way that farmer identifies and defines the real pest problem that needs to be addressed. The first question farmers ask when examining what pest management option to use is probably "how much is it worth?". With the introduction of olive IPM practices, olive growers have to make a choice between an IPM production system and an old production system often involving pesticide-based conventional methods of pest control. Clearly, adoption of IPM practices, as with any technological innovation, hinges on its economic feasibility. In this situation, a farmer needs estimates of costs and returns of both new or untried IPM practices and conventional practices. However, the decision whether to adopt IPM practices is constrained by limited farm resources. Additionally, an IPM practice may be economically feasible, but the market may not provide enough incentives for the farmer to adopt it. For example, as was discussed above, olive IPM improves the quality of olive products but presently the olive market in Albania offers no price premium for high-quality olive oil.

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[33] In the extreme case, a farmer can become aware of a pest problem even if it is not severe enough to materially affect farmer's objectives.

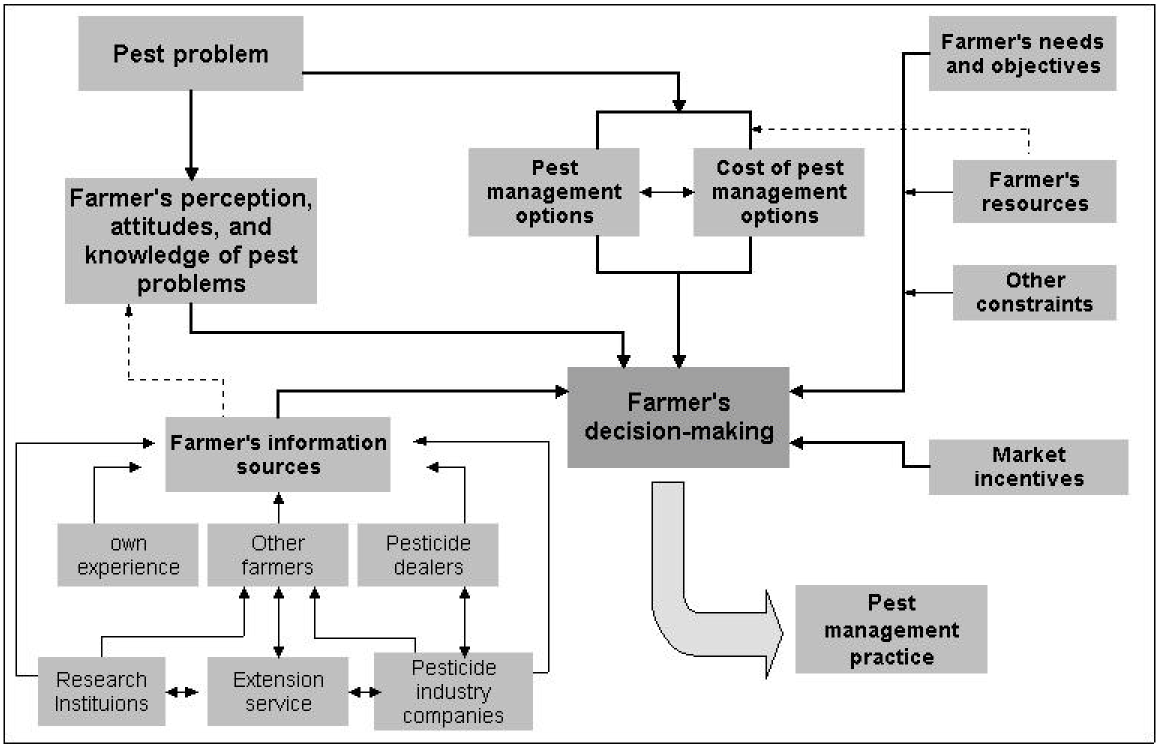

Figure 3.7. Farmer Decision-making Process on IPM Adoption

Farmers' pest management decisions often reflect their individual perceptions of the pest problems that may not reflect the real situation. Information plays a critical role in helping farmers address the most immediate pest problems and choose optimal pest management practices. It has been indicated that producers' choices are significantly affected by exposure to information about the new technology (Feder et al., 1985). Farmers' beliefs and attitudes must be changed and their awareness of IPM must be increased if this new paradigm is going to be promoted. But people's beliefs and attitudes change slowly and to speed up this process, new incentive structures must be examined. Farmers get the pest management-related information from a variety of sources including: research and extension specialists, pesticide industry representatives, pesticide dealers, other farmers and their own experience. Some of these informational sources can hinder the farmer's awareness of IPM due to vested interest. Strong linkages between farmers and research and extension along with education programs can be an effective alternative to financial incentives in encouraging IPM adoption.

Application of the IPM practices on olives is facilitated by several factors (Katsoyannos, 1992): (i) a limited number of pests to control; (ii) a prevalence of monophagous key species; (iii) the stability in the harmful species and beneficial insects throughout thousands of years of plant/pest co-evolution; (iv) a high host plant tolerance to pest damage (the economic threshold); and (v) good plant capacity to recover from pest damage. However, being a multidimensional and integrated innovation, IPM does not have a visible "output". For example, if a grower uses pest resistant varieties as a substitute for chemical control without paying attention to other integrated practices such as pest scouting and monitoring, preservation of natural enemies and so forth, the results of adopting only a single-practice innovation may not be clearly evident.

It is not enough to know what the level of adoption is but what are the impacts of adoption. For example, adoption of synthetic pesticides in the 1950's in USA was considered a great success but later on it was realized that the philosophy was misguided due to environmental and health costs involved (Rogers 1995). Therefore, it is not adoption *per se,* but its impacts that count. Analyzing the relative importance of factors that influence olive growers *ex ante* choices to adopt IPM practices can help decision makers on directions and measures of intervention to speed up the adoption process once the package of IPM practices is available for diffusion.

3.5.2 The analytical model

Since Rogers' pioneer study, the importance of modeling adoption as a dynamic process in which adopters update information about technology over time through "learning by doing" has been emphasized by a number of researchers (see Feder and Umali, 1993 for a review). Modeling IPM adoption in a dynamic setting may not be appropriate for this study because the olive IPM program is in the experimental stage in the study area. The process of information accumulation about IPM is in the initial stages as well. No assessment of potential benefits of olive IPM is present and therefore olive growers base their willingness to adopt olive IPM on their perceived benefits of IPM adoption under incomplete information.

The following model of olive IPM adoption is similar to previous adoption models under output uncertainty (eg. Saha et al., 1994). The point of departure for the present model is the examination of the effects on adoption of farmers' risk attitudes and their perceptions of riskiness of IPM using the expected mean-variance (EV) approach. The model of IPM adoption can be formulated as a portfolio problem of farm resource (the number of olive trees) allocation between a known production system with conventional pest control (CPC) strategies and an unknown alternative production system with the IPM strategies. Such a resource allocation assumption is realistic for the study area because farmers own olives scattered in several locations. According to the baseline survey conducted in 1999, the number of these plots ranges from one to six with forty-two percent of respondents having their olive trees scattered in 3-4 different locations (Daku et al., 2000). To the extent that pest mobility is involved and collective actions by olive growers are not present, the assumption of divisibility of olive trees between the old and new pest control strategies may not quite be justified. However, olive growers have incomplete information about olive IPM strategies. Therefore, given the uncertainty surrounding IPM, it is unlikely that farmers are willing to devote all the olive trees they own to IPM from the outset. At best, initially they may be willing to try only a few olive IPM practices in a limited number of olive trees.

Assume the farm resource base is divisible and therefore the total number of olive trees (T) can be divided into the number of olive trees to be exposed to the IPM (T_N) and the number of olive trees treated with the CPC practices (T_C). The outcomes with the IPM olive production system are assumed to be uncertain in the presence of farmer's incomplete knowledge and information concerning the IPM practices. The production system under conventional pesticide-based pest control practices is assumed to be a known strategy. The olive grower's strictly concave utility function[34] can be expressed as:

$$U = U\left[p\,(R_C, R_N \ell); I^{\circ}; \Psi\right] \tag{3.62}$$

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[34] A well behaved utility function implies $\partial U(\cdot)/\partial p \rangle 0,\ \partial U^2(\cdot)/\partial p^2 \langle 0$

where U denotes producer's utility, p is the olive grower profit which is composed of two components: R_C, return from olive trees under the CPC strategy and R_N, the return from olive trees exposed to the new IPM strategy, I° is a threshold information level that shows whether the olive grower has heard of olive IPM strategies, and Y represents the olive grower's socieconomic characteristics that can affect adoption.

The income or olive profit in (3.62) can be defined as:

$$p = p\big(f(T_C) + g(T_N)e\big) - wT_C - mT_N \qquad (3.63)$$

where: $Q = f(T_C) + g(T_N)e$ denotes producer's stochastic olive production function, w and m are the per unit variable cost associated with the CPC practices and the IPM practices respectively. The production technology component referring to the CPC is nonstochastic. The adoption of olive IPM depends primarily upon the olive growers' perception of IPM benefits. The output from olive trees exposed to IPM is unknown before adoption and therefore uncertain. This output uncertainty is captured by the stochastic component of the production function, $g(T_N)e$, where e is a random variable with mean zero and variance s_e^2. Producer perceptions regarding the riskiness of the IPM practices are conditional upon acquired information. It is assumed that better-informed producers are more confident of the IPM practices' effects and have a smaller perceived variance of olive output under IPM than less informed producers. Therefore, the olive output uncertainty associated with the IPM practices depends on the producers' optimal information level I^*, which in turn is determined by those socioeconomic characteristics of the producers, θ, $(\theta \in \Psi)$ that affect the acquisition of IPM-related information $(I^*(q))$. Thus, the uncertainty component in (3.63) can be expressed as $e_{i^*} = e[I^*(q)]$

The adoption of olive IPM may occur only if the expected utility of applying olive IPM practices (EU) exceeds that of the currently used CPC practices (U_0):

$$E\left[U\left\{p(f(T_C)+g(T_N)\underset{i^*}{e})-wT_C-mT_N;\Psi\right\}\right]\geq U_0 \qquad (3.64)$$

If condition (3.64) holds then the olive grower maximizes his expected utility of income (Y) generated through optimal allocation of the number of olive trees exposed to the IPM and the number of olive trees in the CPC system[35]:

$$\begin{aligned}\max_{T_N,T_C} U &= E\left[U(Y)\right]\\ &= E\left[U\left\{p\left(f(T_C)+g(T_N)\underset{i^*}{e}-wT_C-mT_N\right)\right\}\right]\end{aligned} \qquad (3.65)$$

subject to $T_C + T_N = T$

Assuming strictly interior solutions, the first order conditions of (3.65) are given by

$$E\left[U'(\cdot)\left\{pf_C(\cdot)-w\right\}\right]=0 \qquad (3.66a)$$

$$E\left[U'(\cdot)\left\{pg_N(\cdot)\underset{i^*}{e}-m\right\}\right]=0 \qquad (3.66b)$$

where f_C and g_N represent the derivatives of functions. Assuming further that the second-order sufficient conditions for (3.65) are satisfied, the optimal interior solutions are $T_C^* = T_C(p,w)$ and $T_N^* = T_N(p,m)\underset{i^*}{e}$. The optimal choices T_C^* and T_N^* are 'separable' because the first order condition (3.66a) can be solved independently of (3.66b). Note that the optimal number of olive trees under the CPC strategies is determined only by output and input prices and is unaffected by uncertainty considerations. Whereas the optimal number of olive trees exposed to the IPM practices depends positively on price, expected marginal utility and marginal profit, but negatively on input cost and the variance of e. There are two possible corner solutions for T_N^*. One would be if T_N^* =T^*, implying

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[35] It is also assumed that farmer has a secondary objective of risk minimization.

100% adoption of olive IPM. The other is $T_N^* = 0$ where no adoption of IPM takes place. From (3.66b) it is clear that the olive IPM adoption will occur and therefore T_N^* is strictly positive if expected net marginal benefit of adoption exceeds its marginal cost. Following Saha et al. (1994) this condition is written as[36]:

$$E\lfloor g_N(0)\underset{i^*}{e}\rfloor > m \qquad (3.67)$$

3.5.3 The Empirical Model

According to the optimality conditions obtained under the EU model given by (3.67), the olive grower makes an *ex ante* choice to adopt IPM if the perceived adoption net benefit is positive:

$$N^* \equiv E\lfloor g_N(0)e\{I^*(q)\}\rfloor - m > 0 \qquad (3.68)$$

The olive growers' subjective perception about the riskiness of olive IPM represented in (3.68) by *e* and the level of acquired information about IPM are known to producers, but unobservable to economists. The observable elements in (3.68) are the producers' responses to the questions whether they have heard about olive IPM, whether they are willing to adopt the new practices on their olive trees, the set of socio-economic factors related to farmer and the farm, the scale of operation and prices. These observable elements are captured in the following equation:

$$Y_i^* \equiv b'X_i + e_i > 0 \qquad (3.69)$$

where subscript *i* denotes the sample observation corresponding to the ith olive grower, Y_i^* is the latent variable which serves as an unobservable index of the

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[36] An extension of this model that accounts for the effects of farmers' perceived risk of IPM and their risk attitudes on IPM adoption, which is based on the EV model appears in appendix A.

willingness of each producer to adopt olive IPM, X_i is a vector of explanatory variables that are arguments in the utility function, b is a vector of parameters to be estimated, and e_i is the disturbance term. Since Y_i^* is unobservable, the observed pattern of willingness to adopt IPM can be described by a binary variable Y_i, defined as follows: $Y_i = 1$ if $Y_i^* > 0$ and $Y_i = 0$ otherwise. In other words, $Y_i = 1$ denotes the ith producer's *ex ante* choice to adopt olive IPM.

Estimating the relationship between a binary choice variable as defined above and a set of explanatory variables requires a model with the two features: (i) a probability distribution which is confined to the 0-1 range and (ii) the relationship between a probability and the explanatory variables which is non-linear (Maddala, 1992). The probit and logit models are two such binary choice models whose cumulative distribution functions (normal and logistic respectively) possess these two features. On theoretical grounds, it is difficult to justify the choice of one distribution over another (Green, 1993). However, both probit and logit analysis are well-established approaches in the literature on adoption of technology (Fedder et al., 1985). This study uses the logit model.

The probability that the ith producer adopts olive IPM is expressed as follows:

$$\Pr(Y_i = 1) = \Pr(Y_i^* > 0) = \Pr(e_i > -b'X_i) = \Pr(e_i < b'X_i) = F(b'X_i) \qquad (3.70)$$

where F is the cumulative distribution function with ε assumed to be logistic. Thus, under logistic distribution assumption, this probability is:

$$P_i = \Pr(Y_i = 1) = \frac{e^{bX}}{1 + e^{bX}} = \Lambda(b'X) \qquad (3.71)$$

where Λ denotes the logistic cumulative distribution function. The equation (3.71) is the cumulative logistic distribution function, which satisfies the requirement that P_i ranges between zero and one and P_i is non-linearly related to $b'X$. The probability of non-adoption is given as:

$$P_i(Y_i = 0) = P[1 - P(Y_i = 1)] = \frac{1}{1 + \mathrm{e}^{b\mathrm{X}}} \qquad (3.72)$$

The odds ratio, which defines the probability of IPM adoption relative to non-adoption, is given as:

$$\frac{P_i}{1 - P_i} = \mathrm{e}^{b\mathrm{X}} \qquad (3.73)$$

Taking the natural logarithm of both sides of (3.78) results in:

$$L_i = \ln(P_i / 1 - P_i) = bX_i \qquad (3.74)$$

Equation 3.74 implies that the logarithm of the odds ratio is not only linear in X but is also linear in parameters from an estimation standpoint. Logit analysis can also be used to determine changes in the probability of dependent variable due to changes in the explanatory variables. These marginal effects or derivatives of $E[Y_i \mid X_i] = \Lambda(b^{'}X_{i)}$ are (Aldrich and Nelson, 1984; Green, 1995):

$$d = \partial\Lambda(b^{'}X_i)/\partial X_i = \Lambda(b^{'}X_i)[1 - \Lambda(b^{'}X_i)]b = \frac{\mathrm{e}^{b\mathrm{X_i}}}{(1 + \mathrm{e}^{b\mathrm{X_i}})^2} b \qquad (3.75)$$

The logit model is estimated using the maximum likelihood techniques. The likelihood function is formed as (Kennedy, 1996):

$$L = \prod_i \frac{\mathrm{e}^{b\mathrm{X_i}}}{1 + \mathrm{e}^{b\mathrm{X_i}}} \prod_j \frac{1}{1 + \mathrm{e}^{b\mathrm{X_j}}} \qquad (3.76)$$

where the subscript i denotes adopters and j denotes non-adopters. This likelihood function is maximized with respect to β (using an iterative procedure) to obtain the maximum likelihood estimates of β (β^{MLE}). The explanatory variables included in the model are described in the fourth chapter.

3.6 Concluding Remarks

In this chapter an analytical framework for assessing the potential farm and market-level economic impacts of the IPM CRSP program in the Albanian olive sector has been developed. The economic feasibility of olive IPM practices at the farm level is evaluated using enterprise and partial budgeting analysis. A closed-market economic surplus model under alternative specifications of supply, demand and zone-specific conditions is developed to measure the economic benefits from IPM research-induced gains in olive output and quality improvement. The model improves on the previous ES models by considering the economy-wide effects of the simultaneous shift in olive supply and demand due to IPM and accounting for uncertainty and the spatial distribution of benefits. A model of adoption under uncertainty has also been developed to estimate the influence of farmers' perceived risk of IPM and other socio-economic factors on the likely rate of olive IPM adoption.

Chapter 4: Empirical Model

Section 4.1 Introduction

This chapter presents steps and procedures for assessing the economic impacts of olive IPM/CRSP research activities. It consists of eight sections including this introduction. Section 4.2 provides a review of the study area and briefly discusses major development trends of the Albania olive sector as well as its potential to compete in the world olive market. Section 4.3 defines the setting for the evaluation exercise including the olive IPM research objectives, major research themes, evaluation scenarios, and agro-ecological zones where the IPM research is expected to have an impact. Assumptions and data sources used for developing olive enterprise budgets are described in section 4.4. Section 4.5 outlines the procedures followed for computing major components of the economic surplus model and eliciting expert opinions. Section 4.6 highlights the steps for compiling market-related data for economic surplus analysis. Major variables included in the logit model of IPM adoption and data employed for model estimation are presented in section 4.7. Finally, section 4.8 briefly discusses software packages used for performing data analysis in this study.

Section 4.2 Profile of the Study Area

4.2.1 Albanian olive sector

Olives are a major crop in Albania: 60% of the population grows olives, and 22 of the country's 36 districts produce olives. National production averages 33,000 metric tons (MT) per year, but it has been as high as 53,000 MT (FAO, 2000)[37]. The average olive oil production is 4,000 MT per year and in certain years up to 8000 MT has been produced (Figure 4.1). During the last four decades, olive yields have fluctuated greatly varying from 8 to 30 kg per tree and so has the production of raw olives and olive oil. However, applying better management practices and possibly different cultivars could raise olive yields

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[37] Olive statistics reported in this section are taken from the FAO on-line database unless otherwise cited.

by 100% or more (H. Ismaili – personal communication). There is great interest in raising olive oil production and its quality. Production of oil is presently 1,000-1,200 liters per ha, but with proper crop management techniques, this level can be doubled. Prior to 1991, there were more oil processing factories than at present. However, a number of small factories at the village level are functioning.

Referring to Figure 4.1, it is of interest to note three components of the olive production trend for the past four decades. For the period 1961-1967, olive production followed an upward trend. This period coincides with the time when agriculture was still in private ownership in many parts of the country, although the communist campaign of agricultural collectivization was in its peak. Indeed, the year 1967 marks the completion of forced collectivization in Albania. From that year until the late 1980's, there is a distinct downward trend in olive production and yields, even though the area planted with olives increased steadily throughout the same period. Finally, in the last decade following the transition toward a market economy, olive production is characterized by a positive upward trend with a raw olive production of close to 50,000 MT achieved in 2000.

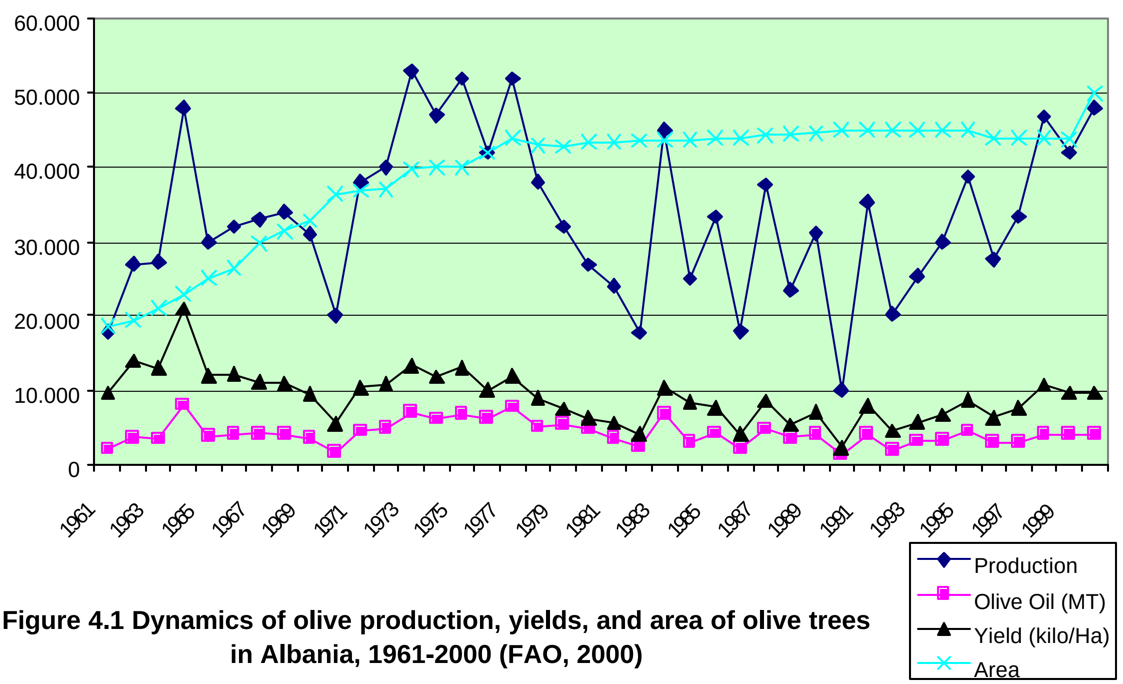

Figure 4.1 Dynamics of olive production, yields, and area of olive trees in Albania, 1961-2000 (FAO, 2000)

In the beginning of the 1990's, there were 5.3 million olive trees in the country, of which 3.3 million were in production. The statistics on the number of olive trees by district and for the country for pre-1990 vs. post-1990 appear contradictory. When the economic changes in the Albanian agriculture started in 1991, the privatization of the fruit tree sector was delayed for a variety of reasons and because of this, some of the best grapevines, orange and apple plantations were destroyed. However, the destruction of olive trees was isolated and not as widespread as with other fruit trees. Contrary to this observation, recent statistics show a much larger decline in the number of olive trees for the last ten years than what appears to have actually occurred. At best, the olive statistics for the post-1990 period are unreliable. For example, as the data presented below show, it is hard to believe that the number of trees in Vlora decreased by nearly half in ten years, while in some other districts the decline in the number of trees varies only between 5% and 20%. Data for the district of Elbasan are a paradox. Olive data for this district show that the total number of olive trees in 1996 compared to 1986 declined by 126,000 while the number of olive trees in production increased by the same amount (!). Also for the country as a whole, data for 1996 show that Albania has nearly two millions less olive trees than in 1986 (AUT, 1987; MAF, 1997).

	Total Number of olive trees (000)			*In production (000)*		
	1986	*1996*	*Difference*	*1986*	*1996*	*Difference*
Vlora	830	463	-367	624	412	-212
Elbasan	551	425	-126	276	403	+127
Albania	5,300	3,405	-1,895	3,333	3,084	-249

For the reasons explained above, this study uses olive data from 1990 as its baseline. Furthermore, the olive statistics for 1990 are more reliable than the present statistics because they are based on more accurate figures that were obtained from the nationwide census of olive trees that took place in 1986[38]. It

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[38] This nationwide census of olive sector in Albania was conducted and supervised by the Tirana Agricultural University.

is further assumed that the number of olive trees destroyed throughout the country during the period 1991-2000 is offset by the new olive plantings during the same period.

Albanian olive production and World olive market

Albania ranked 14th and 17th in the world in 2000 in terms of the area harvested and raw olive production respectively. World production of raw olives for year 1999/2000 reached nearly 14 million tons. Spain and Italy are by far the major olive producing countries, with 31% and 20% respectively of total world production in 2000. Greece (15%), Tunisia (7%), Syria (6%), and Turkey (4%) are also major producers (Figure 4.2a). In terms of area harvested, Spain continued to hold first place in 2000 with 2.2 million hectares or 31% of the total, followed by Italy (20%), Greece (15%), Tunisia (7%), and Syria (4%) (Figure 4.2b).

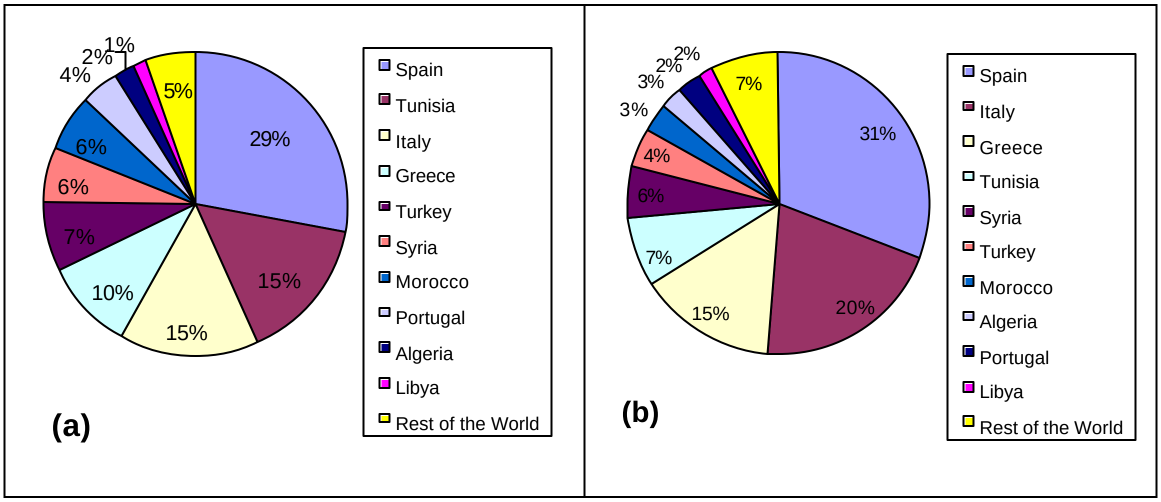

Figure 4.2 World distribution of olive trees (a) and raw olive production (b), 1999/2000 (FAO, 2000; own calculations)

According to the International Olive Oil Council (IOOC, 1997) there are 789 million olive trees worldwide, 95% of them in the Mediterranean region. Olives are grown in other parts of the world as well (Figure 4.3). About 90% of the world's olives are used for olive oil leaving only 10% for table consumption. The most current efforts to promote development of the crop are being made in countries such as South Africa, Australia, the United States (mainly in California), Japan, China, Afghanistan and Pakistan (IOOC, 1997). The increase in such efforts may be related to the change in tastes and perceptions of consumers with respect to table olives and olive oil. For example, during the 1990's there was a growing segment of consumers in nontraditional olive oil consumption countries such as the United States and Japan that came to prefer olive oil to other edible oils.

During the 1990's there has been a considerable increase in world trade of olive oil. In the 1997/1998 crop year the total olive oil traded in international markets was 750,000 tons. Spain continues to be the major exporter of olive oil with a share of 35% of total world exports, followed by Italy, Greece, Tunisia, Turkey and so forth. For the same year, Italy was the largest importer of olive oil accounting for 30% of market share, followed by the United States (22%). The table olive trade is not as important as olive oil trade in the world markets. As with olive oil, Spain is by far the largest table olive exporting country (39%), followed by Morocco (19%) and Greece (15%). Over 350,000 tons were imported in 1998. The United States continues to be the largest importer of table olives (25%) followed by Italy (14%).

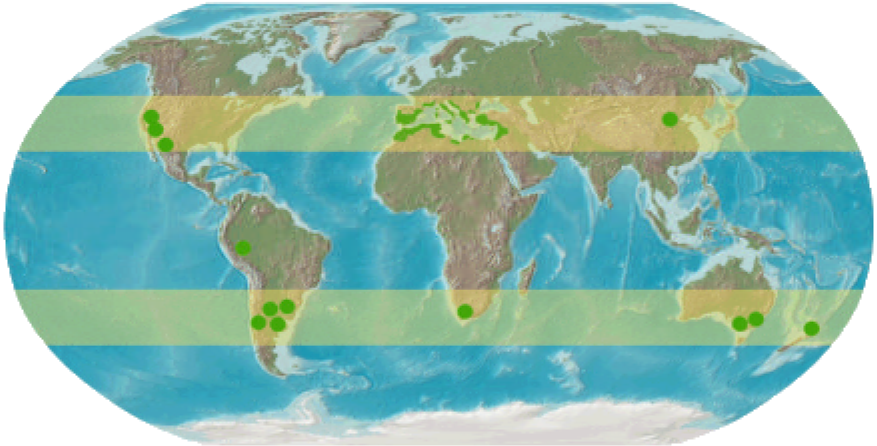

Figure 4.3 Major olive growing regions worldwide (IOOC, 1997)

The volume of Albania's olive products in the world market is limited, if not negligible. As Figure 4.4 shows, during the period 1986-1999, Albania was a net exporter with average exports of 900 tons of olive oil per year and average imports of 550 tons per year. The largest volume of exports was achieved in

1988 (3,300 tons), whereas the largest imports took place in 1993. Data provided by FAO (2000) reported that the country's export of olive oil shrank drastically following the collapse of pyramid schemes in Albania in 1997. In spite of the present unfavorable market and economic conditions, Albania has a great potential for increasing the production of olive oil and the volume of olive product exports. However, its proximity to the European Union countries represents a disadvantage in terms of increasing future olive oil exports. Over 70% of world production and consumption of olive products occurs within the European Union (EU) and given the importance of the olive sector, the EU has adopted very complex subsidy schemes and protection measures.

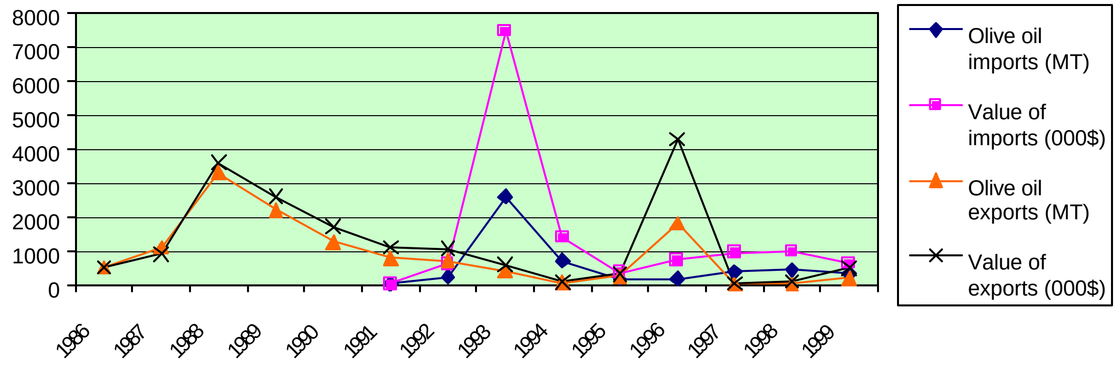

Figure 4.4 Dynamics of olive oil exports and imports in Albania, 1986-1999 (FAO, 2000).

Any changes in those arrangements are likely to have an impact on the European olive industry, affecting world prices and the international supply and demand of olive products. Recently, *The Economist* (June 30th 2001) announced that the EU's system of subsidies for olive producers, which amounts to 2.25 billion Euro a year, is to be extended for the next three years. The result of such an extension will be a further surge in olive production and future new plantings. For example, in addition to the present 300 million trees already bearing fruit in Spain, it is reported that another 40 million Spanish olive trees are expected to enter production. This means that the resource-poor Albanian olive growers will have to face a highly subsidized European olive sector and falling prices. This increase in EU production may make it nearly impossible for Albanian farmers to compete in the world olive markets.

Additionally, presently and in the near future, it is questionable whether the olive oil produced in Albania will meet the strict quality standards imposed by the EU.

4.2.2 Major Olive Growing Regions

Roughly speaking, there are four main olive growing regions in Albania (see Figure 4.5):

(i) ***Ionic region:*** (along the Southern Coastline) which includes Saranda and the Southern part of Vlora. It is considered the area with the highest potential for cultivating olives. It accounts for 38.4% of the country's olive production, 28.6% of total olive groves and 28.8% of total olive trees (Table 4.1). This region mainly cultivates domestic oil varieties such as Kalinjot and Pulazeqin.

(ii) ***Adriatic region:*** (along the Western Coastline) which includes part of Vlora, Fier, Lushnje, Kavaje, Durres, Tirane, and Berat. This region is also considered as an area with high potential and favorable conditions for growing olives. It accounts for roughly half of the country's olive production, total olive groves and total olive trees (Table 4.1). A mixture of table and oil varieties are grown in this region with the most important being the table olive variety called Kokerrmadhi i Berati (Big fruit of Berati).

(iii) ***Near-Adriatic region:*** which includes Tepelene, Elbasan, Kruje, Lezhe, and Shkoder. In these districts, olives are grown only in those plain and valley areas where the temperature is not very low. It accounts for 14.9% of the country's olive production, 18% of total olive groves and 20.1% of total olive trees (Table 4.1).

(iv) ***Interior region*:** which includes Gjirokaster, Permet, Skrapar, and Gramsh. These districts have a low potential for olive production except for some areas where the microclimate allows olive cultivation. Its contribution to olive production is minimal (Table 4.1).

Table 4.1 Olive Production, Olive Orchards and Number of Olive Trees by Districts in Albania, 1986.

Districts	Olive production		Olive orchard		Number of olive trees				Density of olive trees	Olive growing regions by:		
					Total Number		Of which in production:			% of olive production	% of olive area	% of olive trees
	(MT)	(%)	(000 Ha)	(%)	(Trees)	(%)	(Trees)	(%)	(tree/ha)			
Ionic Region		38.4		28.6		28.8		31.4		38.4	28.6	28.8
Sarande	1,634	9.2	5.1	11.4	680,216	12.8	417,000	12.6	127			
Vlore	5,213	29.2	7.7	17.2	830,755	16.0	624,000	18.8	101			
Adriatic Region		46.5		52.2		50.5		52.1		46.5	52.2	50.5
Berat	2,064	11.5	5.4	12.1	741,152	14.0	531,000	16.0	116			
Fier	3,793	21.2	7.8	17.4	813,313	15.3	517,000	15.5	101			
Lushnje	1,178	6.6	2.7	6.1	357,615	6.8	233,000	7.0	128			
Durres	485	2.7	2.9	6.5	298,005	5.5	169,000	5.1	93			
Tirane	803	4.5	4.5	10.1	469,534	8.9	286,000	8.5	96			
Near-Adriatic Region		14.9		18.1		20.1		16.0		14.9	18.1	20.1
Tepelene	274	1.5	0.8	1.8	91,238	1.7	69,000	2.1	101			
Elbasan	1,999	11.2	4.4	9.8	550,975	10.4	276,000	8.3	116			
Kruje	171	1.0	1.6	3.6	155,806	2.7	113,000	3.4	91			
Lezhe	42	0.2	0.3	0.7	33,900	0.7	15,000	0.5	117			
Shkoder	177	1.0	1.0	2.2	246,393	4.6	55,000	1.7	240			
Interior Region		0.2		1.2		0.6		0.5		0.2	1.2	0.6
Gjirokaster	35	0.2	0.1	0.3	14,716	0.3	3,500	0.1	151			
Permet	…	…	0.04	0.3	6,276	0.1	6,000	0.2	74			
Skrapar	…	…	0.04	0.3	4,866	0.1	4,000	0.1	75			
Gramsh	…	…	0.05	0.3	4,937	0.1	2,500	0.1	92			
Albania	17,868	100.0	44.8	100.0	5,299,697	100.0	3,321,000	100.0	111	100.0	100.0	100.0

Source: (AUT, 1987; own calculations).

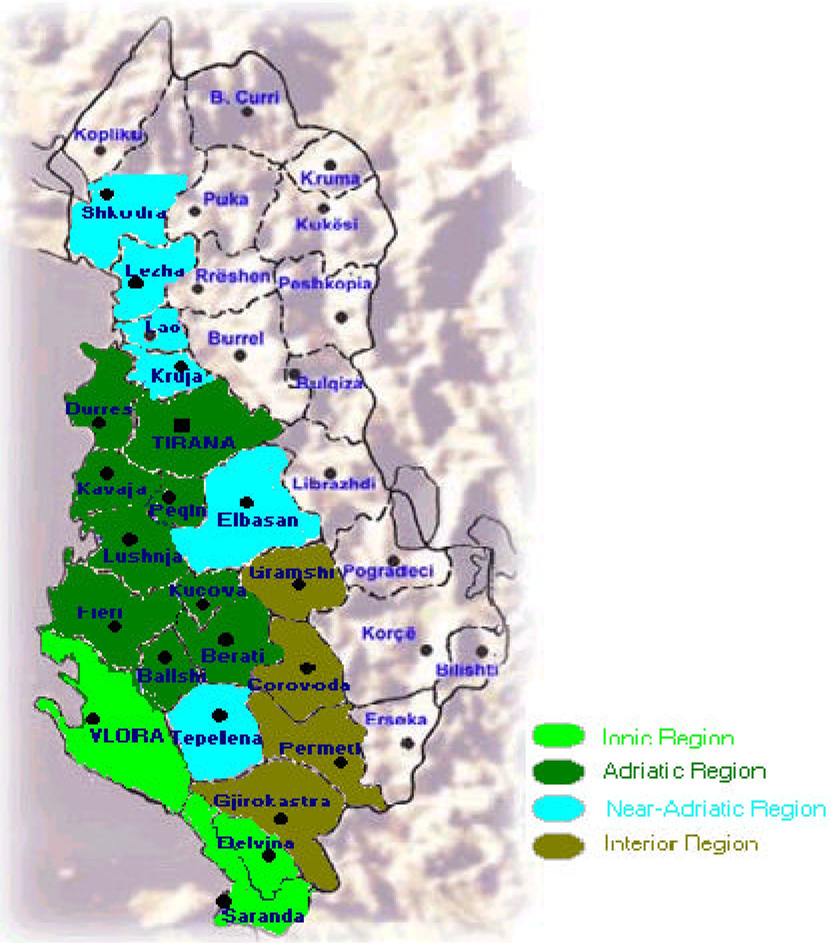

Figure 4.5 Olive growing regions in Albania

Source: Council of Europe, map provided by ReliefWeb <http://www.reliefweb.int/>, own modification.

Table 4.2 gives an overview of the main agro-climatic conditions for the above four olive growing regions. In the first two regions, the summer is dry with little rainfall and the winter is not as severe as in the Northern part of the country. It rarely snows and when it does the snow disappears within a few hours. The sum of active temperatures (>10^{o}C) for the first two regions vary between 4,700 and 5000^{0}C whereas in other regions the active temperatures are lower varying between 3,950 and 4,450^{0}C.

Of the 45,000 ha of olive trees in Albania, 33,500 ha (54.8%) are in traditional extensive olive groves, 1,500 ha (3.3%) are planted intensively, and the remaining 9,800 ha (21.9%) are low-productive olive groves with predominantly wild trees (Thomai, 1999). In terms of the age of trees, half of the olive trees are over 30 years old, 42.2% vary between 11 and 30 years, and the rest are less than 10 years old.

Table 4.2 The agro-climatic conditions of the major olive growing regions in Albania

Agro-climatic indicators	Measuring unit	Major olive growing regions:			
		Ionic	Adriatic	Near-Adriatic	Interior
Sum of active temperatures (>10°C)	°C	5,000	4,700	4,450	3,950
Period of active vegetation	Days	315	276	259	246
Number of sunny days	Days	221	213	209	203
The lowest temperature in January	°C	-0.6	-2.6	-3.3	-5.4
The highest temperature in May	°C	29.7	28.5	30.6	30.2
The average annual temperature	°C	16.9	15.7	15.1	13.9

Source: AUT, 1987

Biennial bearing and a downward trend in the content of olive oil are present in all four major olive growing regions in Albania. As Figure 4.6 shows, there has been notable variation in annual olive production in the last four decades particularly due to biennial bearing. Annual production indexes varied between a minimum of 25.5 and a maximum of 230[39]. This wide range of annual production indexes show that biennial bearing reflects not only the biological feature of the olive crop, but also the low level of management applied in this sector since the 1960's.

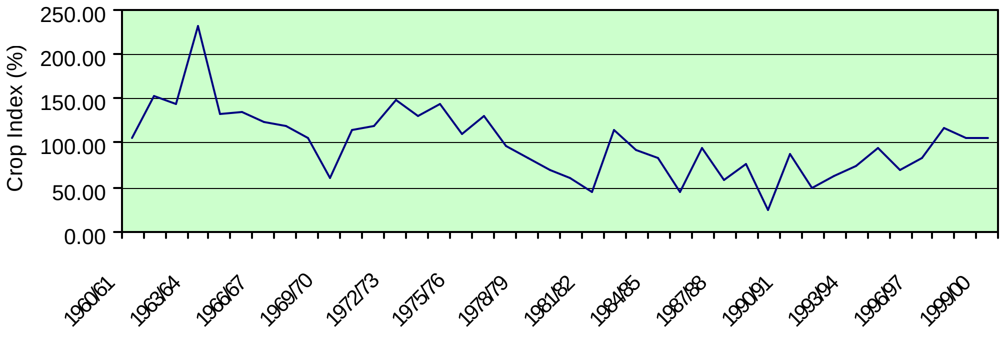

Figure 4.6 Annual crop index for olives in Albania, 1961-2000 (FAO, 2000)

The percentage of oil in olives is a significant indicator of the olive oil production in Albania, given the fact that over 95% of raw olive production is

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[39] (100%=1961-2000 average)

processed for oil and the remaining 4-5% are used for direct consumption. The olive oil content achieved in Albanian olive sector during the period 1961-1986 has had a downward trend (Figure 4.7)[40]. While in the early 1960's the oil content was over 20% (20 kg oil per 100 kg raw olives), in the 1980's, oil content dropped as low as 15%. For the country as a whole, the average olive oil content during the same period is 18%.

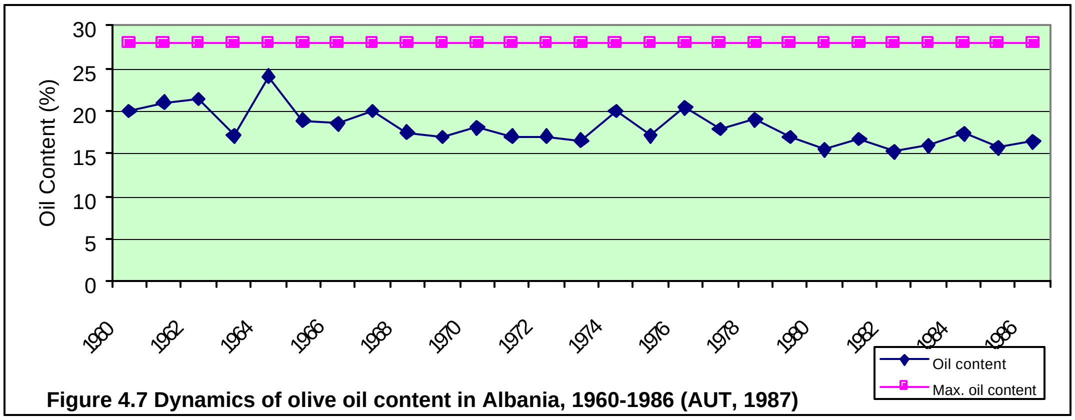

Figure 4.7 Dynamics of olive oil content in Albania, 1960-1986 (AUT, 1987)

Several factors have contributed to the decline of olive oil content (AUT, 1987): (i) pest damage – infestation of olives by olive fruit fly and other olive pests has negatively affected the oil content and quality in spite of heavily used pesticides for their control; (ii) early harvesting – harvest starts in October-November when harvesting time varies with variety and other conditions; (iii) limited processing capacity – the processing industry is unable to process large amounts of raw olives in a short period of time coinciding with the peak of harvest. For this reason, the processing factories exerts pressure on olive growers to start early the harvest so as to spread out the large incoming production; and (iv) processing of table olives for oil – in order to comply with the quotas of olive oil production planned by the government in the early 1980's, many state farms and co-operatives processed for oil the raw olive production coming from table olive varieties which had a lower oil content than oil varieties. Because of these and other technology-related factors, huge loses of olive oil are incurred each year in Albania.

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[40] Data on olive oil content after 1986 are not reported.

4.2.3 Main olive pests

The main olive pests in Albania are (i) olive fruit fly (*Bactrocera oleae*), in Albanian: miza e ulliriti; (ii) black scale (*Saissetia oleae* Bern), in Albanian: breshkeza; (iii) olive moth (*Prays oleae*), in Albanian: tenja; (iv) leaf spot (*Cyclogonium oleae*), in Albanian: syri i palloit, and (v) olive psyllid (*Euphyllura olivine* Costa), in Albanian: psylla (Daku et al., 2000).

Olive fruit fly is one of the key pests causing substantial damage in olive growing regions not only in Albania but all over the Mediterranean area. The major potential economic losses caused by this pest include pre-harvest fruit drop, consumption of fruit pulp by *B. olea* larvae, and reduction of olive oil quality due to increased acidity caused by fungi entering the fruit through the *B. olea* larve exit hole. The damage by this pest also affects the quality of olive fruit. In most cases, attacked fruits are considered unsuitable for marketing. This fact has an important implication in terms of marketability of olive production under an IPM production system. Unlike other fruit trees in which the reduction of pesticide use has been found to negatively affect the cosmetics of fruit, the introduction of IPM for controlling olive fly may improve the cosmetics of olive fruit.

Olive moth is another key olive pest, but not as damaging as olive fruit fly. Losses caused by this pest include: limited damage to the leaves, extended damage to floral buds, two pre-harvest fruit drops (the first occurring after fruit formation and the second after seed hardening). The damage to fruits seems to be more important than the damage to flowers. It has three generations. The first-generation larvae feed on flowers and very young fruit. The second-generation larvae feed on more developed fruit and fruit drop is enhanced. The third-generation larvae feed on leaves and therefore are not as damaging as the first two generations.

Black scale damages olive trees in two ways: by sucking the sap and by secreting honeydew which serves as a substrate for the development of sooty mould. It mainly infests branches. It lays hundreds of eggs inside black port. After development and spread of sooty mould, more damage occurs including the reduction of photosynthesis and respiration in leaves as well as the dropping of leaves. In extreme infestations, it can cause large reduction in yield for a number of years. The scale can become heavily parasitized if the tree is not sprayed. This has happened in Albania. Due to changes in the economic and political system and the reforms that followed in agricultural sector, most farmers cannot afford spraying fruit trees. This has had a positive effect on black scale infestation, which is no longer a problem. The problem is to find a non-disruptive way for controlling olive fruit fly and olive moth that does not disrupt parasitic complex of black scale (Daku et al., 2000).

4.2.4 Vlora district

Vlora district is part of the major olive growing region in Albania. It is located in south of the country along the coastal area of the Adriatic and Ionian seas. It has an area of 1,609 square kilometers. The population is about 170,000 people, of which 53.7% live in rural areas and 46.3% live in urban areas. The main administrative center of the district is Vlora city. The district has three small towns and its rural area is divided into 23 communes and 96 villages.

Table 4.3 The Monthly Average Temperatures and Rainfall
in Vlora, Albania, 1986 (AUT, 1987).

Month	Temperature (^{0}C)	Rainfall (mm)
January	9.0	64.7
February	10.1	126
March	12.8	119.8
April	15.2	29.7
May	19.7	52.8
June	22.2	44.3
July	23.8	6.2
August	25.3	0.0
September	21.6	34.8
October	17.9	74.5
November	13.3	44.4
December	8.7	23.7
Annual Average	16.0	51.74

The district is characterized by a Mediterranean climate with most of the rainfall occurring during the winter and early spring. The monthly average temperature varies from 9 ^{0}C in January to 35 ^{0}C during August. The monthly average rainfall varies from 0 mm in August to 130 mm in February-March

(Table 4.3)[41]. It leads other districts in terms of olive production, area harvested and the number of olive trees. It produces nearly 30% of the country's olives and accounts for 17% of olive groves and 16% of the total olive trees (see Table 4.1).

The study area included the following villages: Bestrove, Cerkovine, Kanine, Panaja, and Tre Vellazen. The area where these villages are located has a high potential for increasing olive production. The importance of olive trees in this area makes it well suited for an evaluation of farmers' knowledge and attitudes towards pesticide use on olive trees and the potential impacts of the introduction of integrated pest management practices.

Table 4.4 Olive Production in Vlora District (Pre-'90 period)[42]

State Farms and Cooperatives[43]	Production (metric tons)					
	1981	1982	1983	1984	1985	1986
NB Ullishte	795	1,566	3,041	364	977	1,300
NB Llakatund	88	233	348	94	172	150
NB Rinia	325	448	837	98	505	400
KB Sherisht	145	276	989	22	146	320
KB Narte	531	814	1,673	132	552	940
KB Tre Vellazen	178	273	588	50	122	150
Subtotal (1+ 6)	2,062	3,610	7,476	760	2,474	3,260
% Over District's Total	31.7	67	47.7	63.3	30.2	62.5
Other Economies	4,439	1,782	8,188	441	5,716	1,953
Vlora District	6,501	5,392	15,664	1,201	8,190	5,213

During the communist regime farmers in those villages were members of socialist cooperatives and state farms. The olive groves in the study area were formerly a part of the state farms: "NB Ullishte" and "NB Rinia" located in the surrounding areas of Vlora city and of cooperatives Sherisht, Narte and Tre Vellazen. Looking at the statistics of olive production in the pre-'90 period, the study area accounted for as much as 67% of the district's olive production (in

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[41] Data presented in tables 4.3-4.6 were provided by the FTRI researcher Dhimiter Panajoti.

[42] We refer to the pre-90 period due to the lack of village and commune-level statistics for the period 1991-1998.

[43] NB stands for Ndermarrje Bujqesore (ex-State Farms)
KB stand for Kooperative Bujqesore (ex-Agricultural Cooperatives)
Former KB Narte included villages of Narte, Panaja, Oshtime, and Kerkove.
Former KB Tre Vellazen included villages of Cerkovine, Skrofotine, and Tre Vellazen.
Former KB Sherisht included villages of Sherisht and Kanine.

1982- see Table 4.4). Also, in most of cooperatives and state farms of the study area, olive yields were well above the district's average yields (Table 4.5).

Table 4.5. Olive Yields in Vlora District (Pre-'90 period)

State Farms and Cooperatives	Yield (kg/tree)					
	1981	1982	1983	1984	1985	1986
NB Ullishte	8.3	14.2	27.4	3	8	10.6
NB Llakatund	6.1	15	20.9	5.6	7.1	6.2
NB Rinia	20.1	23.6	44.1	4.5	17.1	13.5
KB Sherisht	5	8.9	30	0.6	4.1	9.1
KB Narte	14.1	20.8	26.8	2.9	12.3	20.9
KB Tre Vellazen	9.3	13.6	28	2.1	5.1	6.2
Vlora District	15.7	12.1	33.4	2.4	15.6	7.8

The total area available for cropping in the district is 39,400 ha. As Table 4 shows, in 1987, the study area accounted for 34% of the total arable land, nearly 60% of the district's olive groves and 56.4% of the district's number of olive trees (Table 4.6).

Table 4.6 Land Resources and Olive Trees in Vlora District, 1987

State Farms and Cooperatives	Arable Land (ha)	Olive Groves (ha)	Number of Olive Trees
NB Ullishte	2,874	1,613	168,000
NB Llakatund	2,983	674	71,500
NB Rinia	1,893	443	74,000
KB Sherisht	1,743	581	55,000
KB Narte	1,838	768	60,000
KB Tre Vellazen	2,105	480	40,000
Subtotal (1+ 6)	13,436	4,559	468,500
% Over District's Total	34	59.2	56.4
Other Economies	25,964	3,141	361,500
Vlora District	39,400	7700	830,000

The farming systems in the study area are similar to other regions in the southern part of Albania. The most important crops are wheat, maize, vegetables, white beans, alfalfa and other forage crops. The most important fruit trees/vines planted are olives, citrus and grapes. Livestock consists of cattle, sheep, goats, chickens, horses, mules, and donkeys. Almost all households in the study area own one to two milking cows, mostly for home consumption. The surplus milk is sold to the local market, mainly in Vlora city. The majority of families have a vegetable garden with an area that varies between 0.01 and 0.2 ha. They grow tomatoes, peppers, onions, garlic, cabbages, cucumbers, eggplants, and beans mainly to meet the year around family needs. The land is usually tilled using tractors. However, in some of the villages, for example, in Kanine, the land is tilled manually or using animals because the terrain is very steep and plots are small. But even in other villages like Panaja and Cerkovine, where the terrain is flatter, the tractors and implements formerly used on the big state farms and cooperatives are not suitable for the small land holdings.

Section 4.3 Defining the Problem

This section presents the olive IPM CRSP research objectives and identifies major research themes as well as agro-ecological zones where the IPM CRSP research is expected to have an impact.

4.3.1 Objectives of the IPM CRSP/Albania research program

The objectives of the IPM CRSP/Albania research program on olives are to develop improved olive IPM technologies and institutional changes in Albania that will: (i) reduce crop losses; (ii) increase farmer income; (iii) minimize pesticide use by encouraging only appropriate and prudent use according to IPM principles; (iv) minimize pesticide residues; (v) improve IPM research and education program capabilities; (vi) improve ability to monitor pests; and (vii) increase the involvement of women in IPM decision making and program design. These objectives can be categorized into efficiency, equity (distributional) and sustainability objectives. Following the participatory appraisal in July 1998, research, training and information exchange activities relevant to IPM were prioritized and a work plan was derived. At this point, Vlora district was identified to serve as a research site (see the map in Figure 4.8). The field experiments were set up in the summer of 1999.

Figure 4.8 The map of Albania and location of the IPM CRSP research Site.

4.3.2 Major IPM research themes and zones

Following the stakeholders' meeting during the participatory appraisal of olive pest management, the researchers from the U.S. and the three Albanian collaborating institutions identified five multidisciplinary olive pest management research themes. Four of these themes (projects) that involve field experiments are included in this study: (i) harvest timing and olive fly infestation; (ii) vegetation management; (iii) pruning and black scale and olive knot; and (iv) pheromones and non-target species. Two additional (potential) research themes were proposed by researchers to be included in the *ex ante* evaluation process when the expert survey was conducted in the summer of

2000. These potential research themes are: harvesting methods and irrigation. A brief description of each of the research themes follows below[44].

> *Experiment 1 – Harvest timing and olive fruit fly infestation*. This experiment examines the effects of harvest timing on olive fruit fly infestation and olive oil yields and quality. Early in the fall, after temperatures drop below 30^{0}C, olive fly infestation starts increasing. The olive fly infestation decreases oil quality by increasing the percentage of oil acidity in the olive fruit. The increase in oil acidity occurs while olive fruits are maturing and accumulating oil content. The objective of this experiment is thus to determine the optimal harvest timing that insures a maximum of olive oil yield and quality while the effect of olive fly infestation is minimized. Balancing these two processes results in an optimal return to the grower and in a possible reduction in pesticide use for controlling olive fly. Two olive oil varieties were included in this ongoing experiment: Frantio and Kalinjot. Another goal is to study the effects of harvest date on return bloom and yield in the subsequent year.
>
> *Experiment 2 – Vegetation management*. This is one of the most complex research projects of the IPM CRSP/Albania program. Its main objective is to determine the effect of various vegetation management strategies on pest populations and olive yield. Many different types of vegetation, weed species, grass, and shrubs are present in olive orchards in Vlora. This vegetation reduces olive yield and quality by competing directly with the plants for light, water, and nutrients. Weeds are especially damaging to newly established orchards because trees may be killed before they can bear fruit. The vegetation also serves as host to insects and pathogens. Designing optimal weed and pest control strategies that involve a limited use of pesticides might lead to an increase in organic olive products in Albania. Presently, Albanian olive growers are producing pesticide-free olive products, but the yields are low and the whole process is spontaneous, rather than

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[44] The description of major research themes draws from the “Annual Report 2000” of the IPM CRSP/Albania Project as well as from personal communications with Dr. Doug Pfeiffer, the IPM CRSP/Albania site chair.

technology-driven. The research on nitrogen production by cover crops and non-chemical pest management should help increase yields and boost organic olive production.

Two types of weed management strategies are evaluated in this experiment: a conventional strategy using synthetic herbicides and fertilizers and an organic production strategy. The conventional strategy includes: (i) cover crop (mixed legume and rye for winter growth); (ii) untreated control; (iii) non-selective herbicide (glyphosate); (iv) selective herbicide (diuron); (v) grazing; (vi) plowing; and (vii) straw mulch. The organic strategy has five of the above treatments, but does not include the two herbicide treatments used in the conventional strategy. An additional component of this experiment is the use of Bacillus Thuringiensis (BT) to control olive moth and pheromone disruption for insect control. It has been shown that BT can be viable alternative to chemical pesticide use (Katsoyannos, 1992). Direct effects include reduced pesticide use and production cost, sustainable olive moth management, better preservation of natural enemies and a greater enhancement of olive product quality due to low insecticide residue level.

Experiment 3 – Pruning and black scale/optimal treatment for olive leaf spot and olive knot diseases. This research project is related to cultural tactics of controlling olive pests. It has two main objectives: (i) to study the effect of pruning on yield, black scale infestation, and olive knot incidence; and (ii) determine the optimal timing of copper sprays to control olive leaf spot and olive knot diseases. Differential pruning is expected to increase fruiting wood and therefore yield, while allowing greater mortality of black scale, decreasing the need to apply sprays. However, a severe pruning may lead to an increase of olive knot incidence because of a greater number of pruning wounds, which can serve as infection sites for the pathogen. Pruning positively affects spray penetration due to more open tree canopies. Examining the trend of infection levels for olive leaf spot and olive knot throughout the year may lead to a lower level of pesticide use than would otherwise be the case once the growers are able to apply pesticides. Three levels of pruning severity (non pruned, lightly pruned, and heavily pruned) are being tested. Water sensitive papers are attached to branches to measure the level of spray material penetration within tree canopies. Production of fruiting wood and the number of scales for each pruning level are assessed as well. Another component of this experiment is applying monthly treatments with organically acceptable (copper) treatments to determine the best time of spraying to control olive leaf spot and olive knot.

Experiment 4 – Pheromones and olive fruit fly. The objectives of this experiment are to develop an attractant (pheromone)-based control system for olive fruit fly and assess the effects of Eco-Traps on natural enemies that are present in olive groves. Olive fruit fly is the key olive pest in the study area. Prior to the 1990's, heavy applications of insecticides were used to control olive fruit fly in Albania. As a result, adverse effects on human health and the environment occurred in the past. Furthermore, sprays for olive fruit fly disrupt biological control of black scale. In recent years, chemical sprays have not been widely used and most groves now have viable populations of black scale parasites and predators, which should be maintained.

Presently, in this experiment, mass trapping is being used for controlling olive fruit fly. However, the question arises if the new method will be affordable for the country after the project is over. Another problem in Albania is tree orchard fragmentation, which makes it difficult to control for mobile pests like fruit fly (Daku et al., 2000). If this pheromone-based program proves technically and economically feasible, olive fruit fly damage will be minimized without sacrificing biological control of black scale and farmers' income will increase in part due to a reduction in the number of sprays and pesticide residues in olive products.

Experiment 5 & 6 (potential) – Two additional experiments were proposed by the IPM CRSP collaborating scientists to be included in the impact evaluation exercise: (i) effects of harvesting methods on pest infestation, yield and quality of olive oil and (ii) effect of irrigation on yield and quality of olive products. Research on the effects of various harvesting methods on olive production and pest infestation is of great importance in terms of reducing both labor requirements and production costs. Harvesting represents a large proportion of olive production costs (over 50%) and requires a great amount of labor over a short period of time.

Among the most important harvesting methods are collection from the ground, “milking”, “beating” and mechanized harvesting methods (FAO, 1977; p. 206). Harvesting from the ground involves waiting until the fruit falls as it ripens and then picking it up in one or more collection. In the “milking” method, the laborer, stands on the ground or a ladder and either picks the fruit one by one for use as table olives, or when the olives are for oil, with his half-open hand the worker strips off the fruit, which falls on the canvases or plastic nets placed under the tree. “Beating” is the method most used; the worker strikes the top branches of the tree with a staff 3 to 4 m long to knock off the olives, trying to hit the fruiting branches laterally so as to not damage them. The mechanized harvesting methods include machines that are designed to imitate the manual labor of “milking” or beating, and more recently the pneumatic-type machines. Often, the collection from the ground, “milking” and beating methods negatively affect the next year’s yield and quality of olive products as well as the level of infestation of certain pests. For example, collection from the ground is more costly and increases the oil acidity due to delays involved during the harvesting. Beating can lead to an increase in biennial bearing because it destroys a large number of branches, which would yield fruit in the following year. Some of these harvesting methods cause injuries on branches that lead to increase in the black scale infestation and so forth. Studying the effects of these various harvesting methods on yield and quality of olive products as well as pest infestation may be beneficial to olive growers in terms of avoiding those adverse effects and choosing a method that is less costly and with more moderate labor requirements.

Irrigation is an essential input to increasing olive yields. Irrigation of olive groves has rarely been practiced in Albania in the past. This has been the case for several reasons. First, olive is considered a highly drought resistant crop. Second, most olive orchards in Albania are located in hilly areas, which makes it difficult to build an irrigation system due to lack of infrastructure. Third, irrigation in olives requires large initial capital investment especially for the main irrigation canals. Thus, irrigation constitutes an enormous task in the presence of a fragmented olive ownership and extremely small agricultural holdings in the study area and other olive growing regions. However, experience in other Mediterranean countries has shown that irrigated olive orchards can double and even triple the olive production (Katsoyannos, 1992). An examination of the technical and economic feasibility of various irrigation methods in the study area would help farmers increase olive yields and income.

As explained in section 4.1, the four major olive growing zones in Albania include: (i) Ionic zone (Saranda, Delvine, and Vlora), (ii) Adriatic zone (Fier, Mallakaster, Lushnje, Peqin, Kavaje, Durres, Tirane, Kucove, and Berat; (iii) Near-Adriatic zone (Tepelene, Elbasan, Lac, Kruje, Lezhe, and Shkoder); and (iv) Interior zone (Gjirokaster, Permet, Skrapar, and Gramsh).[45] However, only the first three zones are included in this study. The Ionic zone serves as the research target zone because this is the area where the IPM CRSP research is taking place. The Adriatic and Near-Adriatic zones are also important because it is assumed that there will be spillover effects of olive IPM research from the research target zone to other agro-ecological olive growing zones in Albania. The interior zone is not included in the evaluation exercise because its contribution to the country's olive production is very small. These zones differ in terms of agro-ecological conditions such as elevation, rainfall, temperatures, and so forth as well as in terms of number of olive trees, area harvested, olive yields and production. Performing a zone-disaggregated evaluation of potential market-level effects of olive IPM research helps obtain more accurate measures of total research benefits for the country as whole.

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[45] In the early 1990's a revision of the country's administrative division took place resulting in several new districts such as Delvina (out of Saranda district), Mallakastra (out of Fieri district), Kucove (out of Berati district), Peqin and Kavaja (out of Durres district), and Lac (out of Kruja district). This is the reason why such districts do not appear in olive statistics for 1986 as summarized in Table 4.1.

4.3.3 Scenarios

A scenario is a description of the conditions under which a system or policy that is to be analyzed, designed, or evaluated is assumed to perform. The evaluation of potential level and distribution of benefits of IPM CRSP research activities in the Albanian olive sector takes three major scenarios into account:

- *Scenario 1.* (without IPM research/without pesticide). This is called the "do nothing" scenario in terms of pest control. It assumes that olive growers do not spray their olive trees. Farmers have no knowledge whatsoever about olive IPM and other olive cultural operations are applied in a very limited scale.
- *Scenario 2.* (without IPM research/with pesticide). This is the "pesticide-based pest management" scenario. It implies an extrapolation of the current situation of olive production system assuming that the majority of olive growers use pesticide-based conventional practices for controlling olive pests and apply other olive cultural practices.
- *Scenario 3.* (with IPM research). In the "with IPM research" scenario the above six alternative IPM research projects are evaluated against the conventional olive pest control practices. It assumes that the ongoing olive IPM research experiments will be available for dissemination to farmers within a certain period of time.

In summary, the first two scenarios represent an extrapolation of the present "without" research situation, which is further disaggregated into "with" and "without" pesticide use for controlling olive pests. The third scenario considers the "with" IPM research situation.

Section 4.4 Developing Olive Enterprise Budgets

This section presents sample olive tree budgets and respective assumptions for a representative farm in Albania that produces olive for oil, based on projected costs, technology, and management for the 2001 crop year. Three versions of olive enterprise budgets are considered: (i) a pesticide-based budget that assumes farmers apply calendar-based sprayings as well as irrigation in addition to other cultivating practices; (ii) minimum-practice budget that assumes a limited application of chemical treatments for controlling pests in addition to other cultural practices; and (iii) a "do nothing" budget that includes a limited application of cultural practices and no intervention at all for pest control.

The costs per unit area or tree vary widely depending on a number of circumstances: differences in size of holding, fragmentation, topography, availability of labor, ecological situation, condition of groves, varieties, technology and so forth. Because this study seeks to evaluate potential impacts not only in the study area but also in other adjacent olive growing zones, a number of assumptions have to be made as explicitly as possible so as to reflect the possible area-wide variation with respect to olive input requirements, input prices, output prices, crop yields as well as a number of other technical variables.

The following analysis is based on a representative olive farm growing the "kalinjot" oil variety with oil content of 23% for oil production, owning 60 olive trees aged over 20 years, and processing olives only for oil. The owner manages the olive orchard. Given the fact that the age of the trees and the number of trees per hectare vary considerably among major agro-ecological olive growing zones in Albania, the cost figures given below refer to estimates per tree and later on are summarized as costs per hectare. Typically, the cultural practices required for olive oil production are also those used for table olives, especially pruning, fertilization, irrigation, and pest control. The main differences between growing table olives and oil olives are cultivar selection, crop load management for fruit size, harvest maturity, and harvest handling (Vossen, 2000). Table olive cultivars are usually larger with a lower concentration of oil than oil cultivars. Some dual-purpose cultivars are large enough for table fruit and are also high in oil content.

The estimates for input requirements and prices for purchased inputs were based on: current input price data; direct observation in the local markets;

data obtained from the baseline survey and the follow-up survey conducted in the study area in 1999 and 2000 respectively; the previous olive expenditure records of the FTRI; the ongoing olive field experiments of IPM CRSP/Albania project; and an expert opinion survey. The following are the assumptions made in this study with regard to variable and fixed costs of olive production:

- *Land and olive trees* - The farm consists of 1.4 hectares of land, of which 0.5 ha are planted to olives and the rest to other crops. The 60 trees that the farm owns are located in three different plots. Land is not depreciated. Olive trees have a long production life if they are well managed. If cultivated in optimal conditions, the "Kalinjot" variety gives over 30% oil content, but in this study the oil content is assumed 23% in order to account for the lower oil content of table olive varieties present in other olive growing areas. New plantings are not included in this analysis. The tree density is estimated at about 120 trees per hectare.
- *Labor* – Hourly wages for workers are 100lek and 60lek per hour for skilled and field workers respectively.[46] These rates do not include additional benefits such as social security, health insurance and other benefits because these benefits are unusual for temporarily hired agricultural workers in Albania. Wages for operations involving machinery are 20% higher than other operations to account for extra labor involved in equipment set up, moving, maintenance, work breaks, and repair. Wages for management are not included as a cash overhead cost because the orchard is farmed by the owner.
- *Production cultural practices* – (i) *Pruning* is critical to olive production and is dependent on several factors such as olive variety, planting density, and volume of the crown. In this study, pruning is done in the spring by hand. Pruning one tree is estimated to take 0.8 hours. Branches are placed in the row middles and the estimated disposal time is 0.1 hour per tree; (ii) *Irrigation* includes cost of water plus labor. Olive trees need very little water to survive. However, for a good crop, mature

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[46] Normally, paid workers are rarely used in olive production in Albania. The hourly wage estimates in this study are based on the opportunity cost of labor in other agriculture-related professions observed in the labor market in Albania.

olives generally need at least two waterings. The estimated cost of water is 10lek/tree and the operation time is 0.26 hours/tree. Presently, olive trees in Albania are not irrigated. However, water cost estimates are needed to establish the best management practices budget; (iii) *Fertilization* includes nitrogen and manure. Nitrogen fertilizer is applied in a granular form, urea (46% nitrogen) at a rate of 1 kg of nitrogen per tree every two years. The amount of fertilizer used is shown as half the rate or 0.5 kg of Nitrogen per tree annually. Manure is applied to olives at a rate of 60 kg per tree every three years. But the manure applied is shown as one third the rate or 20 kg of manure per tree annually; (iv) *Pest management* - It is assumed that farmer sprays trees with chemicals to control for olive pests. The pesticide-based pest control measures include: (i) two sprays with Dimethoate (40%) to control olive fruit fly, one applied in spring and one in the fall; (ii) two sprays with Copper hydroxide (53%) for control of leaf spot; (iii) one spray with carbaryl (50%) to control black scale; (iv) one spray with dimethoat (40%) to control olive moth; and (v) two herbicide sprays: one with diuron (50%) in Feb/March and another with glyphosate (36%) in April/May as well as plowing raw middles in the spring are applied to control for weeds (see Table 4.9). The present rate to hire a trained worker to spray trees is 4,000lek/ha for eight hours. Usually the hired laborer has an additional assistant and therefore the labor requirement for one spray is estimated 16 hours per hectare or 0.13 hour per tree.

- *Harvest* - Olives are harvested manually in Albania. Beating the tree is the most widespread harvest method followed by the “milking” method. Mechanized harvesting is non-existent. The harvest involves a number of small operations. No matter which method is employed (“beating” or “milking”), the olive fruits are collected on canvases or nets placed below the tree. The harvest is mixed with leaves, shoots, dry twigs, and mud. The fruits are cleaned, placed in sacks, and transported either directly to the processing factory or to the farmer’s house. All of these operations except for transportation are carried out manually and are therefore very labor-intensive. The man-hours required for each of these operations depend on a number of factors such as yield, age of the tree, the volume of the crown, the end-use of harvest (table olive vs. oil) and so forth. For example, the higher the yield, the more time is needed for harvesting. Given an average volume of the crown and a yield of 20 kg/tree, one worker that performs all of the above harvest operations is estimated to pick up 60 kilos in 8 hours, which implies 2.7 hours to harvest one tree. Based on the baseline survey, the average cost of transport of olives harvested from olive orchard to farmhouse is 16lek/100 kg.

- *Processing* – Processing olives for olive oil is done in special processing facilities that use different processing techniques. There are also traditional home processing methods but nowadays such methods are rarely employed because of the extensive use of labor and the resulting low quality of oil. Presently, almost all olive growers process olives for oil in the nearest processing facilities. The majority of farmers pay processors for the cost of pressing the olives and market the oil themselves. A small number sell the olives directly to a processor when this is possible. In this study, it is assumed that all farmers pay for processing and sell oil themselves. From the surveys conducted in the study area it was estimated that on average farmers pay 800lek/100 kg for pressing and processing and 75lek/100 kg for transporting olives from farmhouse to processing factories. In addition, 75lek/100kg oil is paid for transporting oil from processing factory to farmhouse or market.
- *Yields* – Unlike other olive producing countries in the Mediterranean region, olive yields in Albania have historically been reported in kg per tree and not per hectare. Table 4.7 shows that for the period 1950-1990, the average olive yield for the country as a whole was 20.5 kg/tree. As noted in section 4.1, olive statistics for the post-1990 period are unreliable. Therefore, the estimated yield of 20 kg per tree is based on yields reported for the pre-'90 period as well as the data from the surveys conducted in the study area in the past two years (see also Table 4.5). This yield estimate accounts for the effects of biennial bearing as well (see section 4.1).

Table 4.7 Dynamics of olive yields and production in Albania, 1951-1990.

Years	**Olive Yields (kilo/tree)**	**Olive Production (000 Ton)**
1951-1955	12.8	60.4
1956-1960	12.4	62
1961-1965	25.9	129.6
1966-1970	15.3	76.5
1971-1975	20.48	102.4
1976-1980	20.14	100.7
1981-1985	26.74	133.7
1986-1990	30.6	153

Source: Albanian Statistics Yearbook, 1991.

- *Output price* - The output prices used for olive oil were the five-year average of monthly prices reported for the country as a whole (see subsection 4.6.2 below) from 1997-2000. which are 325lek/kg, 370lek/kg, 368lek/kg, 364lek/kg, 360lek/kg respectively[47]. This five-year average was used as expected prices in order to eliminate from consideration the market fluctuations that have been observed in the price of olive oil in domestic market during the last decade.

Overhead costs

Overhead costs consist of cash overhead costs and capital recovery costs. Cash overhead costs are cash expenses paid out during the year that are related to the whole farm business and not to a particular operation. These costs include property taxes, interest on operating capital, insurance, management services, equipment repairs and so forth. Such costs are not included in the estimated olive budgets because the majority of olive growing farms in Albania are involved in small-scale operations and these cash payments are non-existent[48].

Capital recovery costs represent annual ownership costs for equipment used in olive production. The capital recovery cost is the amount of money required each year to recover the difference between the purchase price of a given machinery or tool and salvage value. Salvage value is an estimate of the remaining value (if any) of an investment (tractors or machinery) at the end its life. In this study, the capital-recovery costs for pruning, spraying, and harvesting tools are estimated using the straight-line depreciation and

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[47] Lek is Albanian currency. The average exchange rate for the last two years (2000-2001) is: 1 USD = 145 Lek.

[48] No property taxes are imposed on trees and land.

opportunity cost approach (AAEA, 1998, p. 6-17). According to this approach, economic depreciation and opportunity cost are estimated using formulas (4.1) and (4.2):

$$D = \frac{V_0 - V_n}{n} = \frac{PP - SV}{n} \qquad (4.1)$$

and

$$OC = \left(\frac{V_0 + V_n + D}{2} \right)(r) = \left(\frac{PP + SV + D}{2} \right)(r) \qquad (4.2)$$

where:
V_0 = value of asset at the beginning of period 1
V_n = value of assest at the end of period n
D = Straight-line economic depreciation occurring in each period
PP = Purchasing price of asset at beginning of the first period
SV = Salvage value of asset at end of period n
OC = Opportunity interest cost
r = real interest rate (assumed 6% in this study)
n = time period in years

In this study, salvage value for pruning scissors, hand sprayer, harvesting nets, and baskets is assumed zero and a 6% real interest rate is used to compute the asset's opportunity cost. Note that the estimated capital-recovery costs (CRC) for pruning scissors and hand sprayer are shown as one third the annual CRC because they are used on grapes and other fruit trees as well. Whereas for irrigation system, one half of the annual CRC is reflected in the budget since it is assumed that only 0.5 of 1.4 ha of farmland is planted with olives[49]. The estimates of the capital recovery costs for major olive-related investment and equipment are shown in Table 4.8.

Table 4.8 Annual Investment and equipment costs

Asset/ equipment	Price (lek/unit)	Years life	Salvage value (lek)	Interest rate (%)	Economic depreciation	Opportunity cost	Capital Recovery Cost
Pruning scissors	2,500	10	0	6	250	83	333
Hand sprayer	4,000	15	0	6	267	128	395
Harvesting nets	500	5	0	6	100	18	118
Baskets	200	5	0	6	40	7	47
Irrigation system	10,000	40	1,000	6	225	337	562

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[49] The country's average farm size is 1.4 ha (Daku, 1997).

Changes in input requirements associated with research experiments

The estimated changes in input requirements and input costs associated with each research experiments of IMP CRSP/Albania project was done by employing the same assumption as those described above. The experiments related to harvest timing, harvesting methods, and irrigation of olives do not require any change with respect to chemical treatment. Based on expert judgments, the methods of harvesting experiment would require a 30% increase in the cost of harvesting tools while the irrigation experiment would require a 50% increase in the cost of irrigation systems.

The vegetation management experiment examines a conventional and an organic weed and insect control system. The weed control involves: (i) two sprays: one with Glyphosate (36%); a non-selective herbicide-roundup and another spray with Diuron (50%); a selective herbicide TOTERBANE 50 F applied after plowing; (ii) two irrigations; (iii) two plowings done by tillage between trees, using a three wheeled tractor and by hand under the olive trees to depth of 20 cm; (iv) Straw mulch that is applied before weeds germinate using a mixture of wheat and bean straw; and (v) cultivation of cover crop-mixed legume and rye for winter growth. The organic field had all of the above treatments, excluding the two herbicide treatments. Additionally, in this experiment, Bt products were used to control olive moth compared with a broad-spectrum insecticide BI 58 (Dimethoate 40%) widely used in Albania. Regarding olive fruit fly, different bait treatment were tested, protein hydrolysate + natural pyrethrum in the organic production system and protein hydrolysate + BI 58 in the conventional system.

The pruning/black scale/leaf spot/olive knot experiment involved monthly treatments with copper fungicides for the period October-May to determine the best moment of spraying to control leaf spot and olive knot. However, only the cost of one treatment is accounted for in terms of expected changes in input costs. The pheromone experiment compares use of pheromone (lure and kill device) and the conventional treatment with Dimethoate (40%) for controlling olive fruit fly. It involves additional cost for purchasing Eco-Trap, which are placed in each tree at the end of June before first flight of olive flyand again during the first days of September. The price of one Eco-Trap is 140lek.

The estimates of chemical treatment and other additional costs for conventional pest control system as well as for each alternative research experiment appear in Table 4.9.

Table 4.9 Estimates of pesticide treatments and additional expenses for each experiment

Experiments and input requirements	**Spray solution (% a.i)**	**Spray volume (litre/tree)**	**Spray solution (kg/tree)**	**Number of Treatments**	**Total solution applied (kg/tree)**	**Price of pesticide (lek/kg)**	**Cost of pesticide used (lek)**	**Labor (hours/tree)**	**Machinery (hours/tree)**	**Labor/machinery cost (lek/tree)**	**Cost of Intervention (lek/tree)**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
Conventional pest control											
Olive fruit fly: Dimethoate (40%)	0.2	12	0.024	2	0.048	2500	120	0.13	0.13	65	185
Olive moth: Dimethoate (40%)	0.2	12	0.024	1	0.024	2500	60	0.065	0.065	32.5	92.5
Black scale: Carbaryl (50%)	0.2	12	0.024	1	0.024	2000	48	0.065	0.065	32.5	80.5
Leaf spot: Copper hydroxide (53%) (champion)	0.18	12	0.0216	2	0.0432	3000	129.6	0.13	0.13	65	194.6
Feb/March: diuron (50%)	0.14	12	0.0168	1	0.0168	3000	50.4	0.13		7.8	58.2
April/May: Glyphosate (36%)	0.14	12	0.0168	1	0.0168	3000	50.4	0.13		7.8	58.2
Total							**458.4**	**0.65**	**0.39**	**210.6**	**669**
Harvest timing & olive fly infestation											
No pesticide treatment;											0
Vegetation management											0
Version 1 (conventional):											0
Feb/March: diuron (50%)	0.14	10	0.014	1	0.014	3000	42	0.13		7.8	49.8
April/May: Glyphosate (36%)	0.14	10	0.014	1	0.014	3000	42	0.13		7.8	49.8
April: copper hydroxide (53%) (champion)	0.18	10	0.018	1	0.018	3000	54	0.065	0.065	32.5	86.5
Version 2 (organic practices)											
April: copper hydroxide (53%) (champion)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
Total							**202.8**	**0.39**	**0.13**	**80.6**	**283.4**
Plowing (two times instead of one in conventional practices)				Operation Time (hrs/tree)	Cash and labor costs per olive tree						
					hourly wage	Labor cost/tree	Material (100kg/tree)	Price (lek/unit)	Material cost lek/tree	Fuel, Lube & repairs	Total
Straw Mulch				0.33	60	19.8	1.25	50	62.5	12.5	94.8
Plowing				0.55	33	18.15			0		18.15
Cover crop				0.55	33	18.15	0.01	5000	50		68.15
Grazing (no expenditure)						0			0		0
Total				**1.43**		**56.1**			**112.5**	**12.5**	**181.1**

Table 4.9 (continued…)

May Dimethoate (40%)	0.2	12	0.024	1	0.024	2500	60	0.065	0.065	32.5	92.5
May: Bacillus thuringiencis (BT)	0.15	12	0.018	1	0.018	4000	72	0.065	0.065	32.5	104.5
Note: Dimethoate (40%) in and Bacillus Thuringiensis (BT) in Vegetation experiment are applied for controlling olive moth and therefore should not be included in costs for this experiment											
Pruning, blacks scale, & olive knot infestation											
October: copper hydroxide (53%)	0.18	12	0.0216	2	0.0432	3000	129.6	0.13	0.13	65	194.6
November: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
December: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
January: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
February: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
March: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
March: copper hydroxide (53%) (separate block)	0.18	12	0.0216	2	0.0432	3000	129.6	0.13	0.13	65	194.6
April: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
May: copper hydroxide (53%)	0.18	12	0.0216	1	0.0216	3000	64.8	0.065	0.065	32.5	97.3
Choose cost of one application only **Total**	**0.18**	**12**	**0.0216**	**1**	**0.0216**	**3000**	**64.8**	**0.065**	**0.065**	**32.5**	**97.3**
Pheromones and non-target species											
Version 1 (convencional)											
Dimethoate (40%)	0.2	12	0.024	1	0.024	2500	60	0.13	0.13	65	125
Version 2											
Eco-trap (pheromone)			1	1	1	140	140	0.033		2	142
Total							**204**	**0.163**		**67**	**271**
Harvesting methods & pest infestation											
No chemical treatment; 10% increase in cost of harvesting tools			0		0		0				0
Irrigation and olive production											
No chemical treatment; 25% increase in cost of irrigations system			0		0		0				0

NOTES:

Column (b): percentage of active ingredients in spray solution
Column (c): spray volume for one treatment (liter/tree)
Column (d) = column (b) x column (c)
Column (f) = column (d) x column (e)

Column (i) and (j): labor + machine cost: 4000lek/ha/spray;
labor cost per hour = 4000/16 = 250 lek/hour;
8hrs+8hrs (worker + sprayer); total 16 hrs/spray/ha;
labor & machine hours = 16/120 = 0.13 hour/tree

Section 4.5 Measuring research induced shift in supply and demand

4.5.1 Expected gain in yield (K_t) and product quality (G_t)

Following the economic surplus model specified in chapter 3, zone-specific economic benefits of IPM CRSP research are evaluated through its simultaneous impact on olive supply and demand. These IPM research-induced shifts in supply and demand curves are equivalent to the following two components:

a. The proportional downward supply shift in each year expressed either as a horizontal shift (yield gain) or as a vertical shift (cost reduction), K_t[50]

b. The proportional rightward demand shift in each year expressed as a vertical shift in price of commodity, G_t

The zone-specific proportional downward supply shift in each year, k_{jt}, is calculated as the product of probability of research success, i.e. probability of net yield gains exceeding the dissemination threshold, $P[k_j>k_j^a)$, the expected net yield gain conditional upon the dissemination threshold being exceeded $(E[k_j \mid k_j>k_j^a]$, the likely rate of adoption, A_{jt}, and the current price of olive oil, P_{j0}, divided by the supply elasticity for the zone, ε[51]

$$k_{jt} = \left\lfloor P(k_j \rangle k_j^a) E(k_{\mathrm{j}} \mid k_{\mathrm{j}} \rangle k_j^a) A_{jt} P_{j0} \right\rfloor / e \qquad (4.3)$$

Allowing for research-induced changes in the use of variable and quasi-fixed inputs, the zone-specific proportional net supply shift, k_{jt}, measured in terms of a cost reduction, is calculated as follows:

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[50] A horizontal (quantity direction) supply shift can be converted to an equivalent vertical (price direction) shift by dividing by the supply elasticity, i.e. $k=j/e$, where j is the percentage shift in the quantity direction (j percent increase in yield) and ε is the supply elasticity. As discussed by Alston et al. (1995), unreasonably large k shifts may be implied by combining a j shift with a very small elasticity. Yield shifts translate into price direction shifts most naturally when supply elasticity is one.

[51] As will be shown below, the industry supply elasticity is assumed to be the same in all olive growing zones included in this study.

$$K_{jt} = \left[\frac{E_j(q)}{e} - \frac{E_j(C)}{1+E_j(q)} - fE_j(F) \right] P_j^s A_{jt} \left(1 - d_{jt}\right) \qquad (4.4)$$

where:

$E(q)$ is the expected proportional change in experimental yield per hectare;

$E(q)/\varepsilon$ is the conversion of experimental yield increase (horizontal shift) into a gross proportional reduction in marginal cost per ton of output (vertical shift);

$E(C)$ is the proportional change in variable input costs per hectare to achieve yield change;

$E(C)/[1+E(q)]$ is the proportional input cost change per ton of output;

f is fraction of pre-research cost per ton of output that accounts for allocable fixed factors;

$E(F)$ is the expected proportional fixed input cost change, if any, per ton of output;

P^s is the probability of research success;

A_t is the adoption rate at year t; and

d_t is the rate of annual depreciation

Subtracting the second and the third terms from the first term in the brackets in equation (4.4) yields the net proportionate change in marginal cost per ton of output. Next, the expected net marginal cost change is multiplied by the probability of research success (P^s), adoption rate (A_t), and the annual depreciation rate (d_t), if any.

The shift in demand in each year resulting from research-induced improvement in product quality is measured in terms of a proportional price increase, G_t. The expected gross increase in the price of commodity, $E(P)$, is assumed to be the same for all olive growing zones included in this study. This net price gain is calculated as follows:

$$G_t = E(P) P_j^s A_{jt} (1 - d_t) \qquad (4.5)$$

4.5.2 Probability of research success

Agricultural research is a high-risk activity. Uncertainty is present in virtually all phases of the agricultural research process. Therefore, the potential of olive IPM CRSP research activities to generate economic benefits is uncertain and can be best represented as a distribution of possible outcomes. In Figure 4.9, k represents the expected yield gain from olive IPM CRSP research. For every k, there is a corresponding probability f(k) which is assumed to have followed a triangular probability distribution. Yield gains are specified in terms of minimum, most likely, and maximum possible outcomes: k_l represents the minimum possible yield gain, k_m is the most likely yield gain and k_h is maximum yield gain. The threshold yield gain necessary for olive IPM CRSP packages to be released for dissemination is k^a.

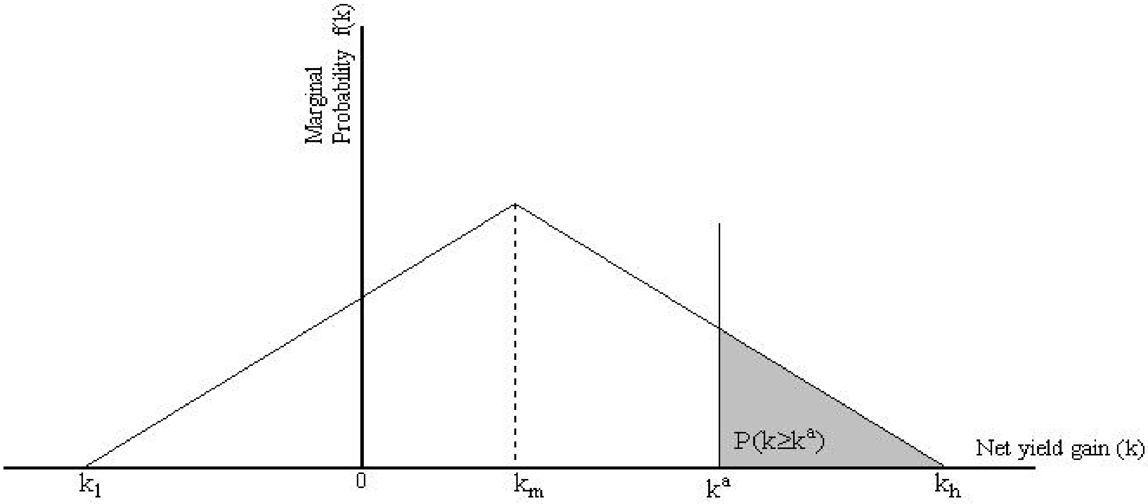

Figure 4.9 The assumed triangular distribution of expected yield gains **(Alston et al., 1995)**

Two parameters are computed from the triangular probability density function of expected yield gains:

a) *Probability of research success*, defined as the probability of exceeding the expected yield gain threshold for the olive IPM CRSP techniques to be released for dissemination.

$$\Pr(k \geq k_a) = 1 - \frac{(k_a - k_l)^2}{(k_h - k_l)(k_m - k_l)} \qquad \text{if} \quad k_l \leq k_a < k_m \qquad (4.6)$$

and

$$\Pr(k \geq k_a) = \frac{(k_h - k_a)^2}{(k_h - k_l)(k_h - k_m)} \qquad \text{if} \quad k_m \leq k_a < k_h \qquad (4.7)$$

b) *Conditional expected yield gain*, defined as the expected yield increase given that the threshold value for dissemination is reached (Mills, 1998).

$$E[k|k \geq k_a] = \frac{\left[\left(\frac{2}{(k_h-k_l)(k_m-k_l)}\right) \bullet \left(\frac{1}{3}k_m^3 - \frac{1}{2}k_m^2 k_l - \frac{1}{3}k_a^3 + \frac{1}{2}k_a^2 k_l\right)\right] + \left[\left(\frac{2}{(k_h-k_l)(k_h-k_m)}\right) \bullet \left(\frac{1}{6}k_h^2 - \frac{1}{2}k_m k_h + \frac{1}{3}k_m^3\right)\right]}{\left[\left(\frac{1}{(k_h-k_l)(k_m-k_l)}\right) \bullet \left(k_m^2 - k_a^2\right)\right] + \left[\left(\frac{1}{(k_h-k_l)(k_h-k_m)}\right) \bullet \left(k_m^2 - k_h^2\right)\right]}$$

for $k_l \leq k_a < k_m$ (4.8)

and

$$E[k|k \geq k_a] = \frac{\left(\frac{1}{3}k_h^3 - k_a^2 k_a + \frac{2}{3}k_a^3\right)}{(k_a^2 - k_h^2)} \qquad (4.9)$$

for $k_m \leq k_a < k_h$

Measuring research-induced net gains in yield and price is the most important step in the evaluation exercise. The size of yield and price gains is a crucial determinant of the total economic benefits from research. In ex-post evaluation studies, these measures are obtained either from using historical and/or experimental data or utilizing the results from previous studies that have used the econometric approach. Being an ex-ante evaluation, measures of supply and demand shift in this study were elicited from a survey of expert conducted with research and extension specialists involved in the IPM CRSP/Albania project[52]. Research and extension specialists were asked to give estimates of k_h, k_l, and k_m for yield and price gains for three scenarios (without research/without pesticides, without research/with pesticides, and with IPM research) as shown in question 1 and 2 below. Also, scientists were asked a third question about dissemination threshold: "*what percentage of net yield gain in olives is necessary to ensure some level of adoption by farmers?*".

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[52] For more details on elicitation process see subsection 4.5.8 of this chapter

Question 1. What is the expected percentage of yield gain from conducting the olive IPM CRSP research for those who adopt the results?

Research Program Area	**Scenario**		**Lowest (%)**			**Most likely (%)**			**Highest (%)**		
			Zone 1	**Zone 2**	**Zone 3**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 1**	**Zone 2**	**Zone 3**
Experiment 1 Effect of harvest timing on olive fly infestation and olive oil yields and quality	With research										
	Without research	With pesticides									
		Without pesticides									
Experiment 1 Effect of vegetation management on pest population and yields	With research										
	Without research	With pesticides									
		Without pesticides									
Experiment 2 … … **Experiment 6** (potential)	With research										
	Without research	With pesticides									
		Without pesticides									

Question 2. What is the expected percentage of increase in price of olive oil due to olive IPM CRSP research-induced improvement in olive oil quality for those who adopt the results?

Research Program Area	**Minimum (%)**			**Most likely (%)**			**Maximum (%)**		
	Region 1	**Region 2**	**Region 3**	**Region 1**	**Region 2**	**Region 3**	**Region 1**	**Region 2**	**Region 3**
Experiment 1 Effect of harvest timing on olive fly infestation and olive oil yields and quality									
Experiment 2 … **Experiment 6** (potential)									

Question 3. Dissemination threshold: what percentage of net yield gain in olives is necessary to ensure some level of adoption by farmers?

Research Program Area	**Dissemination threshold** **(%)**		
	Region 1	**Region 2**	**Region 3**
<u>Experiment 1</u> … <u>Experiment 6</u>			

4.5.3 Expected changes in input costs

As explained in chapter 3 as well as in section 4.4 of this chapter, adoption of olive IPM practices developed by IPM CRSP/Albania project involves changes in input requirements and input costs. These changes are related to the use of additional variable inputs such as pesticides, fertilizers, labor and fixed inputs such as land, harvesting, and pruning tools. These induced changes in input costs must be accounted for in the process of converting the net yield gain attributable to IPM research into cost reduction.

The expected changes in variable and fixed costs associated with each research experiment were estimated using the following data sources[53]: (i) the baseline survey of olive growers conducted in the study area where the IPM CRSP research takes place; farmers were asked questions about the cultural practices and input levels they apply in their own olive groves; (ii) expenditure records for ongoing field-level trials related to olive IPM practices conducted in the study area by IPM CRSP research team; and (iii) the opinions elicited from olive researchers and extension specialists to identify the possible changes in input requirements for each research project. In order to help scientists give more robust estimates about possible percentage change in cost per hectare associated with each experiment, they were provided with benchmark information about the current olive cost structure.

4.5.4 Research lag

The research lag represents time required to complete the research. In other words research and development lags imply a particular time path from when research is initiated to when the new technology package is developed and

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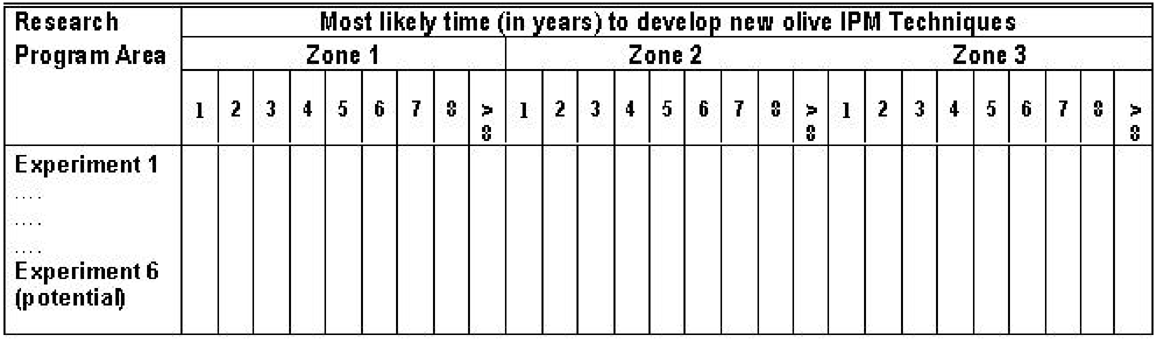
[53] For more details see section 4.4.

ready for dissemination among end-users (see Figure 4.10). The research lags for each research project were elicited by asking scientists to estimate the number of years it would take for the key research results of each experiment to be available to olive growers (see question 4 below).

Question 4. When will key research results of IPM CRSP/Albania project be available to the olive growers?



Research Program Area	Most likely time (in years) to develop new olive IPM Techniques																										
	Zone 1									Zone 2									Zone 3								
	1	2	3	4	5	6	7	8	> 8	1	2	3	4	5	6	7	8	> 8	1	2	3	4	5	6	7	8	> 8
Experiment 1 .... Experiment 6 (potential)																											

4.5.5 Adoption profile

The IPM CRSP research-induced benefits in terms of shifts in olive supply and demand will depend on the rate and extent of adoption of IPM CRSP techniques. Adoption is defined here as the proportion of olive growers who are likely to adopt the new IPM practices after release. Two aspects of adoption are important: the chance that successful research results will be used by farmers and the time it is likely to take for the expected maximum use to occur. The adoption profiles determine the speed and magnitude by which results are translated into an impact on farmers' fields. Therefore, an assessment of the likely adoption pattern of IPM techniques is needed. It is assumed that the potential olive IPM adoption profile follows a non-symmetric trapezoidal lag structure as shown in Figure 4.10 with the following characteristics (Alston et al., 1995):

(i) λ_R - the research development lag ending with the release of the new technology;

(ii) λ_A - adoption lag, a phase of increased adoption, as a growing number of olive growers in the research area become exposed to

IPM technology and decide to use it, measured as years from initial adoption to maximum adoption;

(iii) λ_M – maximum lag, an adoption plateau, where most olive growers have been exposed to IPM technology and have made their decision whether or not to adopt, measured as years from maximum adoption to the start of disadoption; and

(iv) λ_D – declining lag, a declining adoption phase, where IPM technology becomes obsolete, which may not happen.

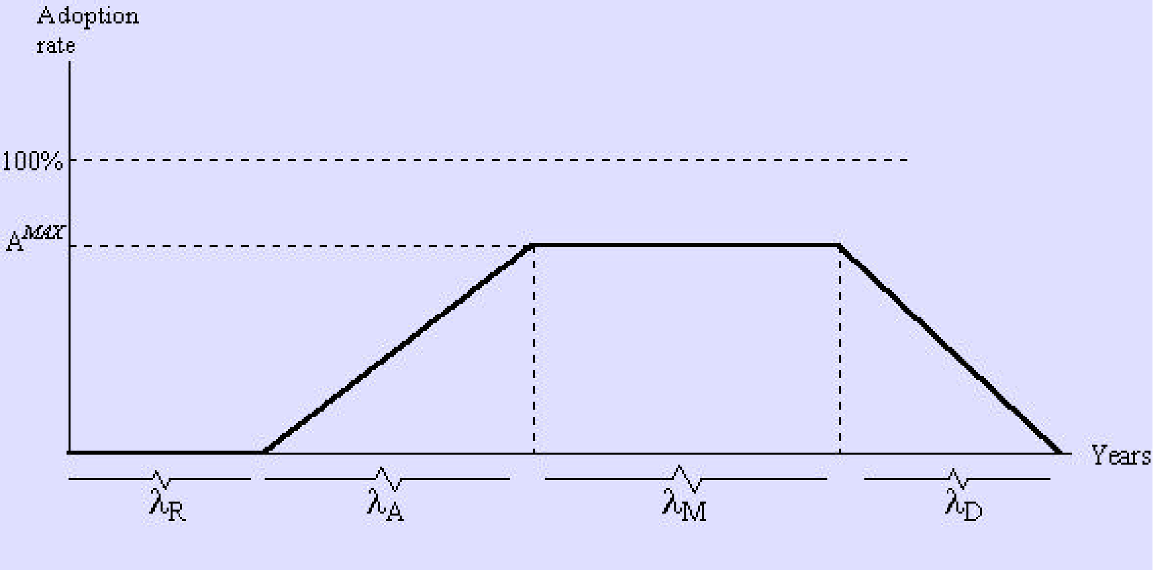


Figure 4.10 Technology Adoption Profile with Trapezoidal Lags

Source: (Alston et al., 1995)

Like the technology potential of IPM CRSP research, the lag structure of olive IPM adoption profile was estimated based on expert opinions of researchers involved in IPM CRSP research. Scientists were asked to specify adoption patterns for each research experiment by agro-ecological zones. The research lag, λ_R, was elicited by asking question 4 described above, whereas adoption, maximum, and declining lags were elicited as shown in questions 5-8 below.

4.5.6 Research costs

Estimates of resources used to conduct each research project are as important as estimates of expected benefits to be reaped from research in order to come up with robust estimates of potential net benefits of research. The research costs are grouped in terms of operational, manpower, and capital expenditure. In addition to four interdisciplinary research activities included in this study for evaluation as described in section 4.3, the IPM CRSP/Albania program has four other research projects: baseline survey; crop/pest monitoring; marketing of olive products; and this study. The total costs of the research were broken down for each research experiment based on the level of expenditure for the past two years as well as the annual budget for the whole research program.

Questions 5-8. What percentage of olive growers are likely to adopt new IPM CRSP techniques after release? How many years after their release do you expect the maximum adoption to occur? Do you expect olive IPM techniques developed by IPM CRSP/Albania project to depreciate and/or become obsolete over time? Yes____No_____; if Yes, how many years after maximum adoption will it take before disadoption starts and how many years will it take to complete disadoption?

Research Program Area	% of Maximum Adoption			Years to maximum adoption			Years Before Disadoption			Years to complete Disadoption		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Experiment 1 Effect of harvest timing on olive fly infestation and olive oil yields and quality												
Experiment 2 .... **Experiment 6**												

4.5.7 Sensitivity analysis

Certain parameters such as per unit cost reduction, change in price, adoption rate, elasticities, discount rate and so forth, used in economic surplus analysis are subject to uncertainty. Allowing these uncertain parameters to vary can provide useful information on the robustness of the results. For those parameters, whose range of values (lowest, most likely or modal, and highest) has been elicited, a distribution of possible net present values was derived for each research experiment in each zone.

4.5.8 Eliciting process of expert opinions

The expert survey for eliciting expert opinions on the potential technology generation of IPM CRSP/Albania research activities was conducted in June 2000. Expert judgments were elicited by interviewing twenty Albanian researchers from the Agricultural University of Tirana (AUT), Plant Protection Research Institute (PPRI) Durres, Fruit Tree Research Institute (FTRI) Vlore, and Ministry of Agricultural and Food (MOAF), Tirana. Detailed elicitation sessions were conducted separately with specialists of the three IPM CRSP collaborating Albanian institutions. The expert judgment elicitation process was based on the Stanford/SRI Assessment Protocol, which consists of the following steps: motivating, structuring, conditioning, encoding, and verifying.

The assessment protocol developed by scientists at Stanford University and at the Stanford Research Institute (SRI) during the 1960's and 1970's is the best known and most influential of the various protocols for expert assessment described in the literature (Morgan and Henrion, 1995). The basic Stanford/SRI interview process consists of five steps as follows:

1. *Motivating*. The objective of this step is building rapport with experts. It explains assessors why elicitation is being done and why an expert assessment is needed. Also, it searches for any motivational biases, i.e. the cases such as: (i) when experts may have a motivation to provide the analyst with an assessment that does not fully or accurately reflect their true beliefs; (ii) when assessors want to appear knowledgeable and be reluctant to acknowledge any uncertainty about outcome; and (iii) when assessors may overstate or understate the risks because of perceived benefit;
2. *Structuring*. The second step of the elicitation process involves structuring the uncertain quantity to be elicited. The goal is to insure that the assessor has a clear definition of the uncertain quantity being elicited. Information made available to the assessor should be clearly defined.

3. *Conditioning*. During the conditioning phase, the objective is to get the assessors conditioned to think fundamentally about their judgments and to avoid cognitive biases. Assessors need to have a clear understanding as to how they will go about making their probability judgments, what evidence they have available, and how they plan to make use of this evidence as a benchmark information.
4. *Encoding*: The fourth step of the protocol involves the actual elicitation (encoding) of the expert judgments. It begins by asking assessors for extreme lower bound and higher bound values of the feasible outcome. Further, assessors are asked to provide a reasoning why the outcome might be lower or higher than the extreme in order to come up with the most likely outcome.
5. *Verification*: This is the final step of the elicitation process during which it is determined if the quantification of judgments given by assessors reflects their beliefs.

Prior to expert interviews, the participants were provided with questionnaires and a brief review of the main objective of and methods involved in the elicitation process. In that review, it was explained that the main purpose of the elicitation is to estimate the time path of olive IPM research-induced supply and demand shifts for each program alternative, which would be used to compute benefit streams. Interviews were conducted at the experts' home institutions following the above five steps of the Stanford/SRI assessment protocol.

The formal elicitation process was preceded by a briefing session. In the first part of the briefing session, researchers were provided with some background information on (i) the socio-economic component of IPM CRSP/Albania project, (ii) the rationale and justification for economic evaluation of IPM programs, and (iii) methodology and procedures to be followed for projecting economic impacts of IPM CRSP research activities on olives as well as for examining the likely patterns of IPM adoption by olive growers. Specifically, the content of the questionnaires and main economic concepts used to estimate potential economic impacts were explained in detail. In order to facilitate a better understanding of key economic concepts by participants, several graphs and figures were used to illustrate major steps underlying economic surplus analysis. Also, as a measure to guard against bias in subjective responses, data series and graphs describing the main trends of country's olive production, area harvested, yields, and price of olive products for the last decade were provided to the assessors. The second part of the briefing session consisted of an extended technical discussion, which lasted in all cases for at least an hour and often lasted for several hours. Discussions often got down to the specific details of each individual question included in the expert questionnaires as well as the scenarios involved in this study.

Once the overall structure of interview had been established, the final stage of interview, the actual elicitations, began. This step took between one and three hours. Initially, experts were asked some warm-up questions in order to insure a smooth elicitation process. For example, they were asked to provide their judgments on the actual and preferred ranking of priorities given in plant protection as well as factors influencing pesticide use in Albania. Then, expert opinions on the potential yield and price gains due to IPM CRSP research, probability of research success, research lags, and adoption profiles were elicited from each scientist using the same format of questions described above in this section.

Section 4.6: Compiling market-related data

The economic surplus analysis in this study requires the following market related data: quantities produced for each olive product, domestic farm level output prices, domestic price elasticities of supply and demand for olive products, and discount rate.

4.6.1 Quantity data

As explained earlier over 90% of olive production in Albania is processed for oil leaving a small part for table consumption. In this study, the total raw olive production in a given year is converted into oil production using an oil content of 23%. The estimate for the baseline quantity of olive oil produced in each olive - growing zone is based on the number of trees in production as reported from the general census in 1987 and the average yield achieved during the last five years[54].

4.6.2 Prices

This study considers the average price for the last seven years (300 lek/kg oil). Figure 4.11 shows the average prices of olive oil reported for the country for the period 1995-2001. This seven-year average was used as expected price in order to eliminate from consideration the market fluctuations that have been observed in the price of olive oil in domestic market during the last decade.

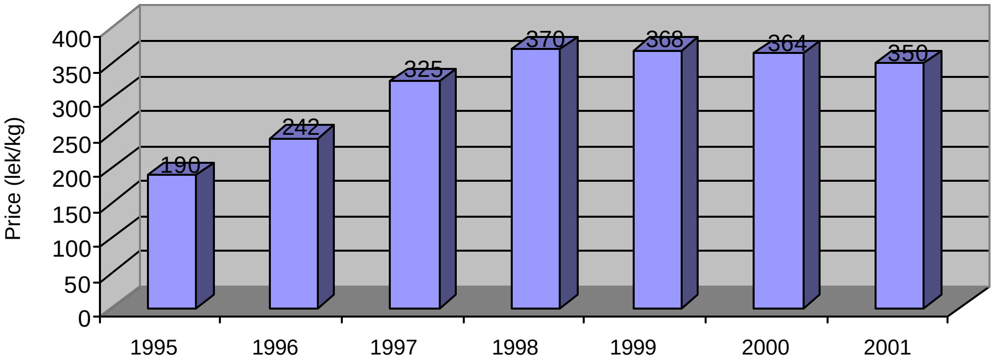


Figure 4.11 Annual average price of olive oil in Albania, 1995-2001 (MOAF, 2001)

4.6.3 Elasticities

Domestic price elasticity of demand for a given commodity can be obtained from: (i) published results of previous studies; (ii) estimation of demand equations; and (iii) approximations using economic theory (Alston et al., 1995; p. 320). Presently, there is no information about demand elasticities for olive products in Albania. Also, no widely published studies that have estimated demand elasticities for olives are available. In this study, it seems that the only feasible option is to approximate demand elasticity for olive products by using economic theory.

Basically, the demand elasticity depends mainly on the commodity. Agricultural products that have a low rate of substitutability and are basic

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[54] The reason for using number of trees in production in 1987 as a baseline is due to unreliability of olive statistics for the post-1990 period. For more details see section 4.1 of this chapter.

products of consumption are likely to have lower demand elasticities than products that have the opposite features. For example, table olives have lower rate of substitutability than olive oil because there are not many substitutes to this commodity and therefore they would have a low demand elasticity. By contrast, olive oil has a high rate of substitutability because it can be easily substituted with other edible oils and therefore it is more likely to have a higher elastic demand than table olives. Taking into account these considerations as well as the assumption made in other studies (see Pinckney, 1991), in this study, the price elasticity of demand for olive oil is assumed –0.8.

Domestic supply elasticities can be obtained from previous studies. As with demand elasticities, information on supply elasticities of olive products in Albania is not available. According to Alston et al. (1995), most published elasticities of supply for agricultural products fall between 0.1 and 1. The supply elasticities depend on a number of factors such as the length of run, the supply elasticity of the factors used to produce a commodity, the ease of factor substitutability and the nature of economies of size and scale in a given industry. For example, the supply of olive products tends to be relatively inelastic because olive trees, having an inherent capital value, are fixed for a time. Therefore, this study assumes a supply elasticity of 1 for olive oil.

4.6.4 Discount rate

In order to compute the present value of the stream of benefits a relevant planning horizon and discount rate must be defined. A discount rate can be determined based on: (i) the economic rate of return on alternative projects or the economic opportunity costs of capital; (ii) the real cost of foreign borrowing when research investment is highly dependent on inflows of foreign capital; (iii) the real rate of return in the capital markets; and/or (iv) the overall demand and supply of investment. Some argue the discount rate should be higher in developing countries than in developed countries because the opportunity costs of capital in the former is higher than in the latter. But the discount rate must be a real rate that does not include inflation. The present rates of capital loans in Albania vary between 10 and 12%. However the country's inflation is highly volatile. Therefore, in this study, the stream of research benefits is calculated using a real discount rate of 6% per year over a planning horizon of 30 years.

Section 4.7 Variables of the Adoption Model

4.7.1 Dependent variable

The logit model specification and estimation was based on two different sets of data and dependent variables. The first model specification was estimated using as a "proxy" dependent variable the adoption of innovative non-chemical olive pest management practices such as the use of trapping for controlling olive fruit fly as well as planting of pest resistant grape cultivars based on the 1999 survey data. The second model specification was estimated using farmers' willingness to adopt IPM practices once they are released as dependent variable based on the 2000 survey data. For this purpose, the question of whether farmers plan to adopt IPM practices was related to two key olive pests (olive fruit fly and black scale) as identified by baseline survey data.

4.7.2 Explanatory variables

The variables used in the logit analysis that are hypothesized to explain the likelihood of olive IPM adoption include farmer characteristics, farm structure/productivity characteristics, managerial practices, and sources of pest management information. A list of explanatory variables and their definitions appear in table 4.10.

Table 4.10 Definitions of explanatory variables used in logit analysis

Variable name	**Description**
AGE	Age of the farm manager [years]
EDU	Education level of farm manager, [1 if no schooling, 2 if elementary school, 3 if middle school, 4 if high school, and 5 if college education]
HCAP	Household education [number of adults with at least high school education]
EXP	Farmers' experience working with olives [years]

FMSZ	Farm size [Ha]
NOTR	Number of olive trees [trees]
FRAG	Fragmentation [number of olive plots a farmer owns]
OMIC	Rank of olive income [1 if olives are major source of income, 0 otherwise]
YIELD	Olive yield [kg/tree]
OILPROD	Olive oil production [litre]
OILSOLD	Olive oil sold [litre]
UPOFT	Spray other fruit trees [1 if sprayed other fruit trees, 0 otherwise]
UPGR	Spray grapes [1 if sprayed grapes, 0 otherwise]
UPOL	Spray olives [1 if sprayed olives, 0 otherwise]
PRUN	Pruning [1 if pruned olive trees as a measure of pest control, 0 otherwise]
TAUT	Tilling [1 if tilled area under the tree, 0 otherwise]
SPR	Sprayer 1 if owns a sprayer, 0 otherwise]
OFFARMW	Off farm workers [no. of full-time off farm workers]
EXTS	Extension [1 if extension specialist is a source of pest management information, 0 otherwise]
RTV	Radio & TV [1 if radio & TV is a source of pest management information, 0 otherwise]
MGNSP	Magazines & Newspapers [1 if magazines & newspaper is a source of pest management information, 0 otherwise]
PDLR	Pesticide dealers [1 if pesticide is a source of pest management information, 0 otherwise]
OFRM	Other farmers [1 if used other farmers or neighbor is a source of pest management information, 0 otherwise]
IPMAWR	IPM Awareness [1 if olive growers have heard of IPM strategies, 0 otherwise]
APHF	Awareness of pesticides harmful environment and health effects [1 if farmer strongly agree pesticides can have harmful effects to environment and human health, 2 if agrees, 3 if no opinion, 4 if disagrees, 5 if strongly disagrees]
RISK[55]	Perceived risk of IPM [1 if farmer strongly agrees that IPM insures more stable olive yields, (i.e. less risky) than conventional pest control system (CPC), 2 if agrees, 3 if no opinion, 4 if disagrees, and 5 if strongly disagrees that IPM is less risky than CPC system]

Education has been shown to significantly induce adoption of soil testing (Fuglie and Bosch, 1995), IPM (Thomas et al., 1988; Harper et al., 1990), and

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[55] For the 2000 data set only

reduced tillage practices (Rahm and Huffman, 1984). In this study, an additional variable, the education level of all household members, has been considered because it gives a more complete representation of household's education attainment. The impact of age and experience on adoption is ambiguous. One strand of research on adoption indicates that older farmers are less likely to adopt technological innovations because of their shorter planning horizon than younger and more educated farmers (D'Souza et al., 1993; Feder and Umali, 1993). The other strand points out that as experience and age increase, these could lead to a better understanding of how IPM integrates into current management practices in a given crop (McNamara et al., 1991). Given these two strands of research, age and experience are hypothesized to have an indeterminate influence (enhance or constrain) on olive IPM adoption. Education level is assumed to positively affect IPM adoption, because better-educated individuals are generally more knowledgeable, more open to information and innovations, and more willing to accept technical and social changes than less educated individuals (Rogers, 1995). A positive attitude concerning the potential of IPM to reduce pesticide use is expected to enhance adoption. On the other hand, if farmers perceive IPM as a risky strategy, this can negatively affect the likelihood of adopting olive IPM. Finally, producers' awareness of IPM is expected to enhance olive IPM adoption because the more information they have about IPM, the less they think of IPM as a risky strategy. Therefore, producers who perceive olive IPM as risky are hypothesized not to be willing to try olive IPM practices.

The farm structures/productivity variables included in the model are farm size [FMSZ], number of olive trees [NOTR], olive grove fragmentation [FRAG], ranking of olives as major source of income [OMIC], olive yield [YIELD], olive oil produced [OILPROD], and olive oil sold [OILSOLD]. These factors may either induce or constrain olive growers' decision to adopt IPM. Farm size has been shown to be an important determinant of the adoption of other productivity enhancing technologies as well as IPM (Thomas et al., 1988; Fedder and Umali, 1993; Dinar et al, 2001). The IPM technology itself is scale neutral, but when compared between small and large farmers with different access to resources then it is not scale neutral anymore (G. W. Norton – personal communication). Number of olive trees is also used as a proxy for the scale of operation that can positively influence IPM adoption decisions because farmers owning a larger number of olive trees are more likely to experiment with new IPM practices than those with a smaller number of trees. Fragmentation of olive groves is expected to positively influence olive IPM adoption because it allows for divisibility of farm resources and therefore for experimenting with some of IPM practices on a small scale. The group of productivity factors such as yield and olive oil produced are expected to positively affect the likelihood of IPM adoption. However, other variables such as olive oil sold and ranking of olives as a major source of income may negatively affect adoption. This is because producers who consider olives as a major source of family income might be more interested in short run economic survival than the future environmental and health gains due to reduction of pesticide use.

Producer management practices are also hypothesized to influence IPM adoption. The components of management practices include use of chemicals on grapes [UPGR], olives [UPOL], and other fruit trees [UPOFT]; pruning [PRUN], tilling of area under tree [TAUT], ownership of sprayer [SPR] and off farm employment. The first three variables related to pesticide use for controlling pests in fruit trees are hypothesized to negatively influence IPM adoption decisions. Farmers who spray grapes and other fruit trees regularly and who own a sprayer are more likely to prefer pesticide-based measures to IPM practices for controlling olive pests. On the other hand, variables of pruning and tilling under the trees are expected to enhance IPM adoption because indirectly these practices represent pesticide-free pest control measures as well. The effect of off-farm employment on adoption decisions has varied in sign. In some studies it has been shown that having other sources of income induces adoption because it minimizes the financial risks associated with trying out new practices (Taylor and Miller, 1978). However, D'Souza et al. (1993) found off-farm employment to negatively influence the decision to adopt a package of sustainable agricultural practices.

Variables related to pest management informational sources included in the model are extension specialists [EXTS], radio and TV [RTV], magazines and newspapers [MGNSP], pesticide dealers [PDLR], neighbors and other farmers

[OFRM]. Producers who contact extension for pest management information and services, read agricultural literature including magazines and newspapers, watch agricultural programs on TV are hypothesized to be more willing to participate in olive IPM program. However, no prior assumption can be made as to the direction of influence for variables MGNSP and OFRM. Use of pesticide dealers as a major source of pest management information is expected to constrain the olive IPM adoption because encouraging the extensive use of pesticides is what pesticide dealers are all about.

4.7.3 Data Sources

As mentioned earlier, the logit model of IPM adoption was estimated using two sets of data obtained from a baseline survey and a follow-up survey conducted in 1999 and 2000 respectively. The baseline survey was an integrated activity of the IPM CRSP/Albania project that describes the socioeconomic context of pest management in olive production in Albania. It was designed to provide background information and context for the ongoing experimental studies carried out by IPM CRSP/Albania. Specifically, the main objectives of the baseline survey were: (i) to identify the farmers' stock of knowledge and farmer perceptions regarding olive pests, natural enemies, and pest management practices, as well as to specify knowledge gaps with respect to olive pest control; (ii) to collect data on the socioeconomic factors that influence pest perceptions, pest management practices and potential constraints to IPM adoption; and (iii) to provide a baseline database needed for evaluation of the economic feasibility of olive IPM practices at the farm level and for the assessment of net project benefits.

The baseline data on farmers' knowledge and attitudes towards pesticide use and olive pest management practices were collected in five villages (Cerkovine, Bestrove, Kanine, Panaja, Tre Vellazen) of Vlora district, in January 1999, using a structured questionnaire. The survey was conducted in Vlora district, because this is the primary research site in Albania where IPM CRSP project activities take place and it is in the heart of the olive growing area. The follow-up survey was designed to collect data needed for examining factors that influence the likelihood of olive IPM adoption. It was conducted in the same study area in the summer of 2000.

4.7.4 Sampling Procedure

The baseline and follow-up surveys were conducted among a sample of Albanian olive growers through the following steps: (i) preparation of questionnaires; (ii) training of enumerators; (iii) selection of villages and sample farm households; (iv) pre-testing of questionnaires; (v) farm household interviews; and (vi) data entry and error checking. Farm households were selected in each village, roughly based on the village population (Table 4.11) and the number of olive trees each household owns following the procedures of stratified sampling. The intention was that the sample of the households selected for interviews be representative of the whole study area.

Table 4.11. Population and number of households in the study area, 1997

Villages	No. of Households	Population
Bestrove	178	900
Panaja	265	1,700
Oshtime	130	750
Kerkove	120	620
Cerkovine	170	952
Tre Vellazen	350	2,100
Skrofotine	157	830
Sherishte	200	680
Kanine	400	2,340

4.7.5 Survey Design

The questionnaire for the baseline survey was developed based on a previous version that had been used to study the pest management practices in rice and vegetables at the Philippine IPM CRSP research site in 1995. Most of the questions from this previous version were modified to fit the specific features of the olive production system in Albania. Additional questions concerning marketing, credit, institutional, and informational constraints faced by the olive growers in the study area were added.

The questionnaire, which is included in Appendix C, is divided into eight sections. The first section requests background information on olive production systems. The second section asks about the pest management decision making within the household regarding the purchase of pesticides, pest control, and marketing of agricultural products. The third section is concerned with factors affecting pesticide use. The farmers were asked to give information about the level of olive production, olive yields, marketable surplus olive oil, olive processing technologies, transport and processing expenditures, marketing of olive oil and the constraints they face. Questions also were included about the amount spent for purchasing pesticides, the importance of various factors affecting their choice of pesticides for different crops, borrowing and credit opportunities as well as constraints they face for getting credit.

Section four requests farmers' perceptions about the effects of pesticides on human health and the environment. Section five deals with farmers' knowledge about olive pests and their natural enemies. Farmers were asked about the olive pests they know, the nature of the damage they cause on olive trees and fruits, the natural enemies of olive pests and their respective role, and their opinion on effects of pesticides on natural enemies. Section six asks for information about the olive pest management practices including the olive pests encountered during the last season, methods for controlling those pests, use of pesticides, timing of pesticide application, the effects of pesticides on those pests, and spraying equipment. Farmers also were asked to list the reasons for not applying pesticides on olive trees.

Section seven addresses sources of information used by farmers in their decisions with respect to olive pest control. Farmers were asked to identify the most important sources of pest control advice, as well as about their participation in training courses. Questions were also included about the adequacy of information they receive, and innovative cultural, production and pest control practices that they have introduced into the olive production system. The eighth section asks about the farmer's socioeconomic characteristics including level of education, years of experience working with olives, tenure status, age, household size, membership in farm organizations, and major income sources.

The questionnaire for the follow-up survey was much shorter that that of the baseline survey (A copy of this questionnaire appears in appendix C). It was intended to secure data needed for estimating the adoption model. It includes questions related to olive growers' characteristics, farm structures, major olive management practices, and institutional/informational factors. For both surveys, the questionnaires were translated into Albanian and were pre-tested on ten to fifteen farmers to ensure that each question was appropriate for and understandable by farmers. After the pre-testing, several questions were dropped and additional questions were added or modified in order to come up with the final version. Next, the final versions of the two questionnaires were coded by assigning a given number to each possible response. For the open-ended questions, the possible responses were grouped into broad categories.

4.7.6 Interview Procedures

Farmers' interviews for the baseline survey were conducted from Sunday, January 24 through Sunday, January 31, 1999. The team was made up of 14 research scientists: 4 from AUT, 3 from PPRI, 6 from FTRI, and one from Virginia Tech, USA. Interviews were conducted in the following Vlora villages: Cerkovine, Bestrove, Kanine, Panaja, Tre Vellazen (a list of the study team appears in Appendix 1). The survey was conducted by personal interviews with a sample of 200 farmers in 5 villages. Out of 200 farm households, in a target group survey of 50 households both male and female household heads were interviewed to obtain gender-differentiated data and determine their respective role in pest management decision-making. Overall, 250 questionnaires were completed.

Initially, the team was divided into five combined groups with specialists from each institution. The mixture of the team was changed everyday to avoid some kind of "enumerator or group biases" during the interviews. Farmers interviewed were very cooperative throughout the interview process. The interview process coincided with the peak of olive harvest. Moreover, that year farmers had relatively high olive yields, so that they were very pleased and responsive during the interviews. These circumstances facilitated the interview process. Completed questionnaires were reviewed by the interview team to check for completeness and response consistency. After this review and error checking, data from completed questionnaires were entered into the computer.

Farmers' interviews for the follow-up survey were conducted with a sample of 121 olive growers in the first week of July, 2000. Interviews took place in the following Vlora villages: Cerkovine, Bestrove, Kanine, Panaja, Tre Vellazen. Overall, 121 questionnaires were completed.

Section 4.8: Analyzing data

This study used a spreadsheet (Excel) to estimate farm-level and aggregate economic benefits of IPM CRSP/Albania research. Following methods and procedures described in Chapters three and four, data analysis was performed by setting up separate spreadsheet templates for each experiment to generate partial budgets as well as the streams of research benefits and costs for a closed economy. The resulting estimates of research benefits and costs were converted into summary statistics consisting of NPV, internal rate of return, and the distribution of benefits between groups of producers and consumers. The logit model of IPM adoption was estimated using the software package LIMDEP, which employs the maximum likelihood iterative procedure to obtain parameter estimates.

Chapter 5: Results and Discussion

Section 5.1 Introduction

This chapter presents the results of the baseline survey, net return analysis, and economic surplus and adoption models. The chapter is divided into six sections including the introduction. The second section presents results of the baseline survey, which include a description of the group of socio-economic factors that influence pest perceptions, pest management practices, and potential constraints to IPM adoption in the study area. Sections three and four discuss the results of partial budget analysis and economic surplus model concerning farm and aggregate level impacts of olive IPM CRSP/Albania research program. The results of the logit model that examine the role of risk perceptions and other informational factors on the likely rate of IPM adoption are outlined in section five. Section six highlights major findings and policy implication of the results.

Section 5.2 Results of the Baseline Survey

5.2.1 Socio-Demographic Profile of Farmers Interviewed

Sample size

The survey covered 200 households (HH's) with an average size of 5.7 persons. Of the 200 farmers interviewed in five villages, 34 (17%) were from Bestrove, 45 (22.5%) from Cerkovine, 36 (18%) from Kanine, 54 (27%) from Panaja, and 31 (15.5%) from Tre Vellazen.

Gender and age

Ninety-five percent of those responding to the main questionnaire were male while only 5 percent were female. This area is characterized by heavy migration of men to other countries such as Greece and Italy. The temporary migration of household males increases during the summer time. If the survey were conducted in the summer, the percentage of women respondents would have been much higher due to temporary migration of males. The village of Kanine had the highest proportion (13.8%) of female respondents. The average age of the respondents was 49 years. The age of farmers ranged from 16 to 80 years with the largest percentage (28.5%) falling between 41 to 50 years. The age distribution of respondents was similar among the villages (Table D5.1)[56].

Education level

Farmer education ranged from 0 to 16 years of schooling with an average of 9 years. Of 200 farmers interviewed, only 8 respondents (1.5%) had received no schooling while 8.7% had elementary education, 57.7% had middle school education, 30.4% had high school education, and 1.7% had attended college (Table D5.1).

Household characteristics

Family size of the respondents ranged from 2 to 18 members with the largest percentage (43.5%) falling between 5 and 6 members. The average family size was roughly 6 members while the median family size was 5 members. The largest average family size was found in the village of Panaja (nearly 7 members). Seventy-five percent of working family members reported working full-time or part-time on the farm, while the rest are engaged either in non-farm activities or working abroad. The respondents declared that a shortage of labor exists during the harvesting season of olives (November-January). However, those with insufficient family labor said that they do not use hired labor, but rather their relatives and neighbors help them (Table D5.2).

Farmers' experience with olives

The farmers' experience working with olives ranged from less than 5 years to more than 20 years. The majority of farmers interviewed (nearly 60%) had more than 20 years of experience working with olives, while only 4.5% had less than five years of experience (Table D5.2). However, as it was emphasized in the profile of the study area, most of those private olive growers had been members of socialist cooperatives and state farms for a long period of time. These cooperatives lacked a continuous flow of technical information. Extension services were non-existent. Moreover, men and women working in cooperatives

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[56] Tables 5.1-5.30 appear in appendix D.

and state farms did not have enough incentive to master and apply innovative production techniques. Working for more than four decades in those large and very specialized production structures, they lost their comprehensive farming skills. The indigenous knowledge structures about farming inherited for generations were destroyed. The master farmer was gone. Under these circumstances, the new landowners respond with difficulty to the market economy. Consequently, it is doubtful whether this long experience with olives can be used as evidence of an adequate level of farmers' knowledge about olive production systems.

Farm size

The average farm size is 1.59 ha, while the median farm size is 1.23 ha (Table D5.3). The farm size ranged from 0.1 ha to 12.5 ha with most farmers (68%) having 1.5 ha or below. The farm size distribution differed among the villages. Farmers in Kanine and Bestrove had a smaller average farm size than those in other villages (Table 15). Panaja had the highest average farm size (1.84 ha) and the standard deviation (SD) in farm size for this village was also the largest (1.7 ha).

Number of olive trees

The average number of olive trees owned by farmers is 56 trees. Farmer ownership of olive trees ranged from 8 to 200 trees with the majority of farmers (84%) owning 90 or below (Table D5.4). The distribution of olive tree ownership varied greatly among villages. Bestrove had the highest average number of trees owned by a farmer (85) followed by Kanine (69). Half of the farmers in Bestrove owned more than 78 olive trees. The standard deviation (SD) of the number of olive trees owned by a farmer was the largest (51.1) in Kanine. Cerkovine had the smallest average number of trees owned by a farmer (39), while Panaja and Tre Vellazen were in between with 49 and 51 trees/farmer respectively (Table D5.4).

Sixty-five percent of olive trees owned by farmers are dual-purpose varieties that can be used both for oil and pickling and 33% are oil varieties. Only 2.2% of olive trees owned are from table varieties (Table D5.4). Farmers reported several olive varieties. Among those varieties, Kalinjot was reported by

62% of farmers, followed by Pula Zeqin (27%), Frantoju (8%). The rest (2%) were wild varieties (Table D5.5).

Only 25% of farmers interviewed had planted olive seedlings during the last five years. Cerkovine and Tre Vellazen had the highest number of plantings among sampled villages. One explanation for this level of planting may be the existence of the FTRI experimental fields close to these two villages. Indeed, the majority of respondents (54%) cited the Fruit Tree Research Institute in Vlora as the primary source of olive seedlings. Private growers accounted for 32% of olive seedling supply, followed by traders (8%) and their own plots (6%) (Table D5.5). The olive seedlings were planted in December (29%), January (51%), and February (20%). Given the fact that large olive tree groves lie in the study area, a higher number of new plantings might be expected. Farmers interviewed mentioned several factors that have contributed to this low number of plantings such as the lack of financial means, the lack of a structured market for seedlings, and the long time before they enter production. Even though the FTRI was cited as the primary source of olive seedlings, the FTRI does not have a specialized program for producing seedlings to meet the farmers' demand[57]. No commercial nurseries existed at time of the study.

Other fruit trees

In addition to olives, many farmers in the study area own citrus, grapes and other fruit trees. Almost half of farmers (47.5%) grow grapes (Table D5.6). Panaja had the highest proportion of farmers growing grapes (69%) while Kanine had the smallest (22%). Citrus is not so widespread in the villages sampled. Only 16% of sampled farmers own citrus. An exception was Cerkovine with 36% of farmers growing citrus and selling part of their citrus production on the market. Also, 31.5% of farmers interviewed own other kinds of fruit trees (apples, plums, peaches, pears, figs, nuts) in addition to olives, grapes or citrus (Table D5.6).

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[57] This fact does not necessarily mean that the FTRI should be a source of olive seedlings for private farmers. Commercial nurseries in the private sector are expected to be major providers of olive seedlings in the future.

5.2.2 Olive Production and Income

Olive yields

Farmers reported olive yields ranging from 1.2 to 100 kg/tree. The average olive yield for 1998/99 was 31.1 kg/tree and the distribution of olive yields was skewed toward the higher end. It should be noted that 1998/99 was a good production year for olive growers[58]. The average yield in 1998/1999 was well above the country's average achieved in the past (including pre-1990). Fifty percent of farmers obtained yields ranging from 30 to 100 kg per tree. However, the yields vary greatly among farmers interviewed with the standard deviation (SD) in yield of 18.3 kg/tree. The distribution of olive yield also varies among villages. Panaja reported the highest average yield of 35.8 kg/tree (SD:18.8), while Kanine reported the lowest average yield of 28 kg/tree. However, the latter had the widest range of olive yields with a standard deviation of 20.9 kg/tree. This wide range might be an indication that farmers interviewed in that village were somewhat reserved in reporting this information due to tax concerns. Tre Vellazen had the highest median yield, 35 kg/tree (Table D5.7).

Sales

Olives are a cash crop. As Figure 5.1 shows, forty-five percent of the farmers interviewed reported olives as the most important source of income while another 38.5% of respondents ranked olives as the second most important source of income (see also Tables D5.8).

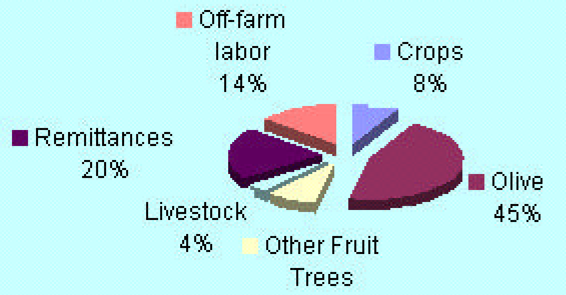

Figure 5.1. Farmers' Most Important Source of Income (sampled farmers) Vlora, Albania, 1999.

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[58] As noted earlier, olive trees normally exhibit biennial bearing: each year of high yield is followed by a year of low yield.

Other sources of income important to farm families were remittances from migration, non-farm income, income from crops, livestock, and other fruit trees. The ranking of olives as the major source of income differs among the villages. In Tre Vellazen, Bestrove, and Kanine, more than half of the farmers reported olives as the main source of income. In Panaja, olives were ranked the lowest, because farmers in Panaja put a higher value on grapes than on olives. Farmers reported sales of pickled olives and olive oil. Looking at each olive product marketed, the number of farmers selling olive oil is much higher than the number of farmers selling pickled olives. The majority of farmers (60%) marketed part of their olive oil production, while only 4 % of farmers sold pickled olives. This is because the olive trees that are oil varieties are widespread in the study area. In the villages of Kanine and Tre Vellazen farmers reported no sale of pickled olives.

Of 309.2 MT olives produced by sampled farmers during 1998/99, 28 MT (9.1%) were used for family consumption, 280.2 MT (90.6%) were processed for oil and only 1 MT (0.3%) was sold in the market as pickled olives with an average price of 178 lek/kilo[59] (Table D5.9).

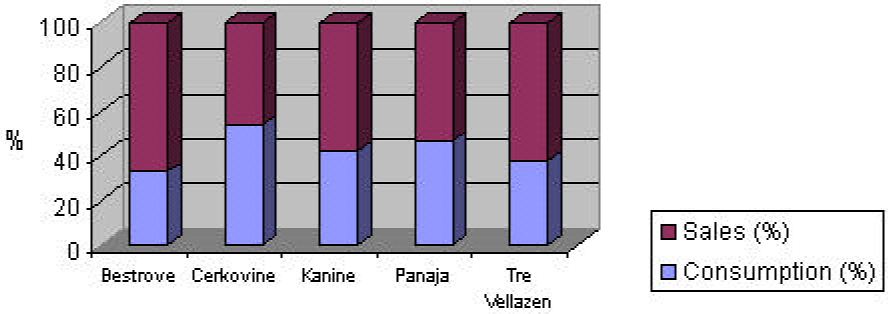

Figure 5.2 Sales and Consumption of Olive Oil by Sampled Farmers, Vlora, Albania, 1999.

Farmers extracted 65.3 MT of olive oil with an average oil content of 23.3%. The largest portion of the olive oil produced (38 MT or 58.3%), was sold in the market and the remainder (41.7%) was used for family consumption (Figure 5.2). Olive oil sold in the market received an average price of 302.5 lek per liter. During the interviews, many farmers stated that they set aside more olive oil

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[59] Lek is Albanian currency. The exchange rate at the time the Baseline Survey was conducted (January 1999) was: 1 USD = 145 Lek. The present rate (April 2002) is: 1 USD = 140 Lek.

than they needed for the annual family consumption due to periodicity of olive production. The quantity of olive oil sold varies among the villages. Farmers in Bestrove reported the highest percentage sale of olive oil (67.5%) while farmers in Cerkovine reported the lowest sale (46.2%).

Farmers also are engaged in selling part of the production from other fruit trees. However, with exception of grapes, the marketable surplus from other fruit crops is relatively small compared to that of olives. Relatively speaking, the marketable surplus of grapes and olives is similar (Figure 5.3). In absolute terms, the quantity sold and income received from the olive sales account for a larger share in the total farmers' income than that from grapes.

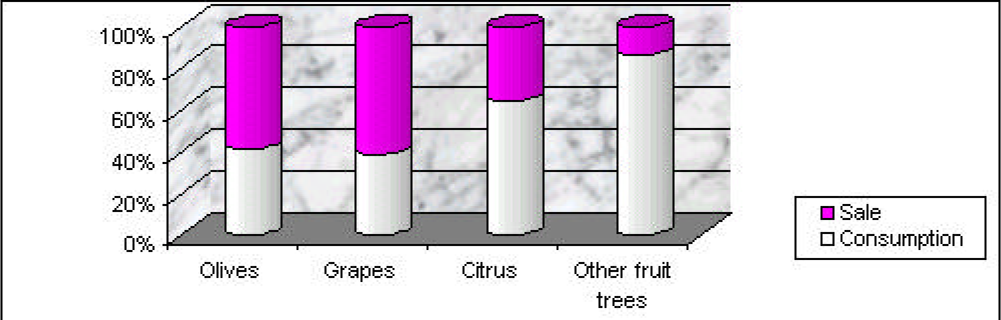

Figure 5.3. Consumption and Sales in Fruit Tree Production (sampled farmers), Vlora, Albania, 1999.

Income

The farmer income from pickled olive sales in 1998/99 ranged from 2,000 to 140,000 lek/farmer with the majority of farmers (55.5%) receiving between 10,000 and 80,000 lek/ha. The average reported income from pickled olive sales was 60,222 lek per farmer (Table D5.10). However, it should be emphasized that the income from pickled olives does not account for a substantial share of the total farm income from olives because only a small number of farmers reported sales of this commodity[60]. Instead, it is the income from olive oil sales that constitutes the major share of income from olives. Farm income from olive oil sales for the production year 1998/99 ranged from 6,000 to 540,000 lek, with half of the farmers receiving between 72,500 and 540,000 lek (Table D5.10). The average reported income from olive oil sales for the same

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[60] But it may be important for some, however.

season was 98,815 lek/farmer. The distribution of olive oil income varies greatly among farmers with a SD of 84,909 lek/farmer. The distribution of olive oil income also differed among villages. Bestrove had the highest average level of income at 140,978 lek/farmer, while Cerkovine had the lowest figure (76,875 lek/farmer), which is close to half of the income level for farmers in Bestrove. However, Cerkovine has the widest range of income among farmers with SD of 113,901 lek/farmer.

5.2.3 Agricultural Support Services

Marketing

Fifty-eight percent of olive oil is sold in the market indicating that olive is a cash crop for most of the farmers. However, more than half of the respondents reported that the prices are low and structured markets for olive products are non-existent. No link exists between wholesale and retail markets as well as between local and regional markets for olive products. Packing of pickled olives and bottling of olive oil is done in a very primitive way, not according to hygienic standards. No price differentiation is applied with regard to different grades and quality of olive oil produced by farmers. When the survey was conducted, it was noticed that while the local markets in the study area seemed overwhelmed with olive oil, in other parts of the country one could see obvious shortages for the same product. Little has been done so far to facilitate the creation of marketing channels.

The availability of market information is generally limited. Coming from a centralized economy, in which the state took responsibility for every aspect of their work, private farmers generally know very little about output markets for agricultural products. Many of them seemed to only have experience with selling products privately at the local market and few institutionalized marketing agencies have been developed so far. The lack of cooperative institutions has also contributed to the underdevelopment of domestic olive markets. Indeed, farmers interviewed reported no affiliation with any farmer organization.

The overwhelming majority of farmers (99%) processed the olives for oil in factories. Only two farmers reported home processing. Eight olive processing factories were reported functioning in the villages sampled (Table D5.11). Panaja had the highest number of factories (3), followed by Kanine (2), and the remaining villages had one factory each. The majority of farmers (57.4%) reported that the number and capacity of factories was not enough to meet farmers' increasing demand for processing olives for oil. Although these factories use modern technologies, farmers wait for many days to process their olives. Many farmers stated that the low processing capacity of factories had affected the quality of oil produced. The factory shortage was more severe in Tre Vellazen, Kanine and Bestrove than in other villages. The average distance from the farm to the processing factory was 3 km. The shortest distance (0.7 km) was reported in Panaja and the longest distance (7 km) was reported in Kanine. Farmers transported their olives mainly by vehicles, but in some cases used donkeys or other animals (Table D5.11).

The low number of processing facilities and the fragmentation of olive trees each farm owns have led to an increase in olive production costs. Farmers spend on average 87 lek/kv[61] for the transport of olives from olive groves to the house and 162 lek/kv for the transport from house to the processing factory. The longer the distance, the more they have to pay for transporting olives. The cost of transportation for Panaja with three factories is half the cost of other villages such as Tre Vellazen, Kanine and Cerkovine with fewer factories. The average amount paid for olive processing was 788 lek/kv. The processing cost was almost the same in all villages sampled. Kanine is an exception. Although the average processing cost was 800 lek/kv, the standard deviation is 162 lek/kv suggesting that farmers in this village had to pay more when they could not find any factory close to their village (Table D5.11). Some farmers in this village stated during the interview that they had to travel as far as 15 km to process their olives for oil. Farmers sold their olive products to five main sources (Table D5.12). Thirty-eight percent of farmers sold olive oil at the local market, 15.5% to the local traders, 14.5% at non-local markets and the rest

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[61] one kv equals 100 kg

(32%) to the olive processors and trade associations. Nearly 30% of farmers reported no sale of olive products (Figure 5.4).

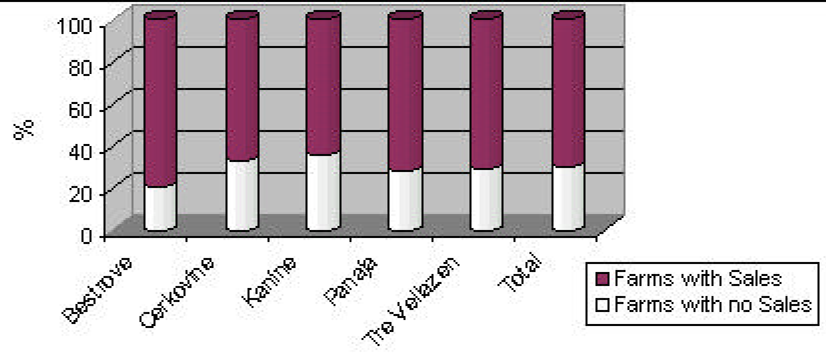

Figure 5.4 Percentage of Sampled Farmers Selling Olive Products in the Market, Vlora, Albania, 1999.

Farmers were asked to list constraints and problems that they face in marketing olive products. The major marketing constraints reported by farmers were the following (Table D5.12): the inability of local markets to absorb the local supply of olive oil and the lack of alternative regional markets to sell olive products for higher prices (70%), the undeveloped network of local collection centers (48%), low domestic prices for olive products (42%), lack of transportation (33%), inadequate conditions and experience to do product standardization, packing and advertising (28%), high costs of transportation (27%), low level of marketing surplus olive products that prevents farmers from establishing continuous links with markets (27%). Only 3.5 % of respondents reported no constraint related to the marketing of olive products.

Credit

Agricultural banking in Albania is in the process of being reformed and therefore is not in a favorable position to meet the credit needs of farmers. It seems that lending to agriculture is entirely under government control. Presently, Albanian farmers have no access to loans at market rates.

Of the 200 farmers interviewed, only one reported to have received credit from a trader. Only 38% of respondents consider it possible to borrow. The rest stated they have not tried to get credit because there are so many constraints and the interest rates are too high. There is a resistance among farmers to using land as collateral. However, since 1993 the collateral, specifically the land title, has become a frequent requirement for obtaining credit. Many farmers have not yet received their title, because the process of registering real property is taking place very slowly. Twenty-two percent of farmers reported that the capital of banks is very limited, so that they cannot cover all the farmers' demand for credit. In addition, a quarter of respondents feel that the bank personnel are corrupt. They mentioned many cases when they were asked to pay bribes in order to obtain credit (Table D5.13).

Another constraint mentioned by farmers is that banks are far away from the village and moreover the bank representatives never travel to rural areas. Also, respondents said the state banks apply many bureaucratic procedures that are hard for them to understand. From discussions with farmers it appears that the present credit system is very unsatisfactory, but many of the respondents nevertheless emphasized their strong need for credit. The overwhelming majority of respondents (85.5%) reported that they would invest in expanding olive groves should they have access to credit (Table D5.13).

Land Tenure

The overwhelming majority of respondents received their land and fruit trees when agricultural cooperatives and state farms were broken up starting in 1991. Private ownership of land is dominant, accounting for almost 100 % of land held by these farmers. Respondents reported no other forms of land tenancy. Not many farmers appeared to have obtained ownership titles for their land. Small farms of 1.2-1.5 ha are prevalent in all villages sampled. These farms usually contain several parcels of land that vary from only one to between three and five parcels. Indeed, farmers interviewed reported that the land fragmentation is a major constraint they face. The majority of the families had their land holdings scattered in several places. The existence of just a few land transactions among farmers due to undeveloped land markets and the absence of other forms of land tenure suggest that this situation will continue unchanged for some time.

Prior to 1991, the socialist cooperatives and state farms were the sole owners of olive trees. The fruit trees were distributed and taken over by private farmers after the decollectivization campaign that started in 1991. The majority of respondents reported that olive trees had been distributed in 1991, while the rest were distributed during the period 1992-1994 (Table D5.14). The overwhelming majority of farmers stated that the olive tree distribution was carried out according to the law, that is, on a per capita basis. There were some cases when certain individuals took possession of the olive trees according to previous original ownership. However, respondents emphasized that the process of tree distribution was in many cases spontaneous and not well organized. This uncontrolled process of privatization brought about several problems that presently are hard to fix. One problem was the widespread damage of fruit tree plantations throughout the country. Another was that farmers received olive trees scattered in several locations (Table D5.14). This scattering ranges from one to six places with forty-two percent of respondents having their olive trees scattered in 3-4 different locations. This is more evident in Bestrove and Panaja.

Information and Training

The surveyed farmers mentioned several sources of pest control advice including radio and TV programs, magazines and other written materials, extension and research specialists, neighbors and relatives, their own judgment and experience, pesticide dealers, and private consultants (Table D5.15). The majority of farmers interviewed reported their own experience as the most credible source of pest control advice or information (Table D5.15). Next, the extension and Department of Agriculture specialists were rated as most important sources by 43% of respondents. However, the majority of farmers (55.5%) reported that they would ask the extension specialists first if an unknown olive pest seriously damaged their olive trees. Although pesticide dealers constitute one of the main sources of advice about pests and pesticides, farmers did not express much faith in their advice. Indeed, only 8% of farmers rated pesticide dealers as the most credible source of pest advice. Also, a number of farmers ranked specialists of research institutes as a credible source of pest control advice. However, they added that these researchers are very busy with experiments and they never seem to come to the field. During the discussions farmers clarified that they value their own experience because there are not other information sources available.

Farmers mentioned various reasons for the credibility of sources of pest information on olives (Table D5.15). Most of respondents indicated extension specialists as the most credible source of advice because they are more knowledgeable, have more experience, have university education, and they tell what and how to do things. However, no farmer interviewed stated that extension specialists were accessible. A small number of respondents also considered research specialists as a credible source of information, but not accessible in most cases. Few respondents mentioned magazines, radio, and television, neighbors, pesticide dealers and own experience as other alternative sources of information.

Farmers were asked to rank the qualities that a source of advice should have in order to be as effective as possible for them. Knowledge was ranked as the first quality a pest advice source should have, followed by experience, university education, practicality, and accessibility (Table D5.16). Only two percent of farmers reported to have participated in a training course related to pest control in olives. However, the overwhelming majority (82.5%) said they are willing to participate in such courses in the future.

Around sixty percent of farmers had never had any contact with agricultural extension specialists since they took over the olive trees (Table 5.16). Only 13% of farmers reported to have contacted a specialist who discussed non-pesticide means of olive pest control (Table D5.17). Eighty-five percent of farmers report to have inadequate access to information (Table D5.17). On the other hand, ninety-eight percent of respondents rank the information and technical assistance as very necessary (Table D5.18).

Farmers interviewed seem to be very nostalgic about the past with respect to the state support for agriculture. More than 88% think that the state support for agriculture should be the same or stronger than before the 90’s (Table D5.18). Farmers were asked whether they had applied any innovative practices in the olive production system since they took over the olive tress from the collective farms. Nearly 40% of respondents reported to have applied some practices while the rest indicated they had introduced nothing new (Table

D5.18). Farmers in Tre Vellazen, Kanine, and Cerkovine appear to be relatively more innovative than farmers in other villages. Nearly half of farmers in Tre Vellazen had applied light and heavy pruning and tilling of the area under the tree. Only a few farmers reported to have used pest resistant cultivars and trapping methods for pest control (Table D5.19).

The majority of farmers (65.3%) mentioned their own experience, neighbors, and other farmers as the major sources of advice for these innovative practices (Table D5.19). This fact is indicative of the poor job that is being done by extension and research institutions to provide technical assistance and information to farmers in the study area. Indeed, this is not the case in this area alone. Farmers mentioned several reasons for not applying innovative practices including lack of financial means, lack of access to credit, and inadequate access to information (Table D5.19). However, most of them stated that they are willing to introduce more innovative practices should the access to information and credit be improved. Because, they added, olives are a major source of family income and they cannot afford to ignore the great income opportunity olives offer them.

5.2.4 Pest Problems and Management Knowledge

Commonly known pests

The olive pests most commonly known by farmers were olive fruit fly (*Bactrocera oleae*, formerly *Dacus oleae* Gumelin), olive psyllid (*Euphyllura olivina* Costa), black scale (*Saissetia oleae* Olivier), olive moth (*Prays oleae* Bern), leaf spot (*Cycloconium oleae* Cast), and olive knot (*Pseudomonas syringae pv savastanoi* (E.F.Smith) Stevens), (Table D5.20). The olive fruit fly is known by an overwhelming majority of farmers (95.5%) while leaf spot is known by only 35% of farmers. Farmers perceive the olive fruit fly as the most damaging olive pest (86%), followed by black scale and olive psyllid (30%), olive moth (23%)[62], olive knot (20.5%), and leaf spot (16.5%) (Table D5.20).

Farmers gave diverse responses regarding the nature of damage caused by olive pests. In many cases their description of pest damages did not match

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[62] This figure for olive moth may not be accurate because many farmers seem to mistake olive psyllid for olive moth.

those of respective pests. Eighty-five percent of respondents think the olive fruit fly damages the olive fruit while 14.5% think this pest damages tree branches and leaves. The majority of farmers think black scale damages tree branches and leaves and just a few farmers think this pest also damages the fruit[63]. The same opinion was expressed about the nature of the damage caused by the olive psyllid. Half of the respondents think that olive moth damages tree branches and leaves while the other half think it damages olive fruit. The overwhelming majority of respondents thought that leaf spot and olive knot damage the tree branches and leaves (Table D5.21).

During the 1998/99 season, olive fruit fly was observed on the olive trees by 88.5% of farmers, followed by olive psyllid, black scale, olive moth, olive knot, and leaf spot (Table D5.22). Olive psyllid seems to be more widespread in Kanine and Bestrove than in other villages. The overwhelming majority of farmers (79.5%) mentioned the olive fruit fly as their most problematic pest in olives followed by olive psyllid and olive moth (Table D5.22). The next highest proportion of farmers (34%) considered the black scale as their number two-pest problem in olives followed by olive psyllid, olive moth, and olive knot (Table D5.22).

Knowledge about natural enemies

Farmers' knowledge about the natural enemies of olive pests was very limited. Even those farmers who responded seemed a little surprised about this question because they had never thought about it. Only 27.5% of respondents were aware of the beneficial or neutral insects and animals, while the rest either were not aware or had no opinion (Table D5.23). Most farmers who know of natural enemies of olive pests don't have a clear-cut answer whether they are killed or die when sprayed with pesticides (Table D5.23).

Perception of pesticide effect on yields

The overwhelming majority of respondents (96.5%) answered that it is necessary to use chemicals to control the olive pests (Table D5.24). Farmers' opinion on the role of pesticides in increasing olive yields is equally divided

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[63] Fruit damage is not characteristic for black scale.

between those that agree and those that have no opinion about it. Only two farmers disagree that the application of pesticides increases olive yields (Table D5.24). Half of those that indicated that application of pesticides increases olive yields think so because they are confident the pesticides they apply do not cause other pest problems (Table D5.24).[64]

Pest Control Measures

Only 22.5 % of farmers used pesticides on olive trees (Table D5.25). However, almost half of the farmers interviewed (46%) had used pesticides on grapes (Table D5.25- Figure 5.5).

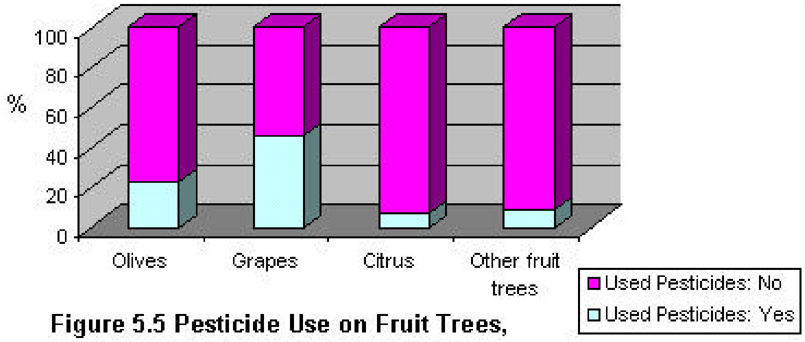

Figure 5.5 Pesticide Use on Fruit Trees, (sampled farmers), Vlora, Albania, 1999.

Other control measures used by farmers were pruning (83.5%), tilling of area under the tree (78.5%), mechanical methods, and the use of resistant varieties. It should be emphasized that the latter were not used as pest control methods per se. However, open pruning increases mortality of black scale and tilling of soil can kill pupees of olive fruit fly. Seventeen percent of farmers reported to have applied no pest control measure (Table D5.25). Sixty-one percent of farmers claimed that their main reason for applying pesticides was to prevent pest and disease infestation (prophylactic treatment), while 39% applied pesticides to control an existing pest infestation (curative treatment) (Table D5.26). The majority of farmers who had applied pesticides believed that the pesticides were effective. However, 24% stated that they did not know about the efficacy of pesticides (Table D5.26).

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[64] In addition to increasing yields, pesticides may improve crop quality but this issue was not addressed in the survey.

Attitudes toward pesticide use

As shown in Figure 5.6, farmers revealed little awareness of the potential harmful effects of pesticides on human health and the environment. The majority of farmers either did not agree or expressed no opinion about whether pesticides can harm water quality. When asked whether the water supply in their area may have been contaminated from the use of pesticides, only a small number of respondents (6.5%) agreed. Many of them seemed surprised and did not believe pesticides are harmful to underground water. Nevertheless, some farmers (8.5%) mentioned cases when their family members had been poisoned while applying pesticides (Table D5.27).

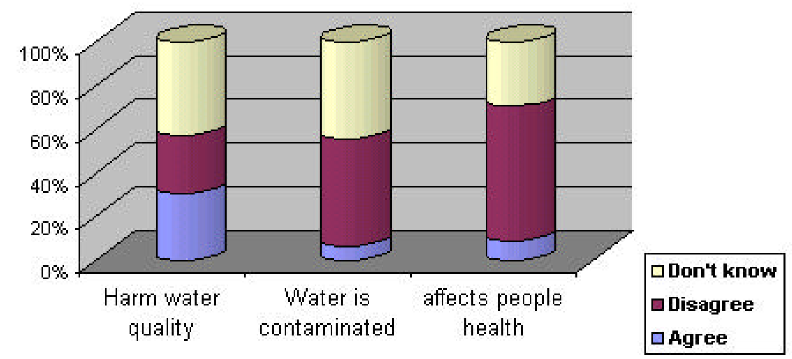

Figure 5.6 Farmer Perceptions of Pesticides' Effects on Human Health/Environment, Vlora, Albania, 1999.

Farmers interviewed gave several reasons for not using pesticides on olives (Table D5.28). The majority of farmers (73.5%) reported high pesticide prices as the main reason. Further they explained that they could not afford chemical treatments in the year that olives give no production. Other reasons mentioned by farmers were: uncertainty about the quality of pesticides supplied by local traders (58.5%), the lack of spraying equipment (46%), other farmers' not using pesticides (33.5%), the lack of knowledge on timing and right mixtures of applying pesticides (20.5%), and the limited availability of pesticides in the local markets (11.5%).

Farmers reported several factors that affect their choice of pesticides (Table D5.28). The overwhelming majority of respondents (83%) ranked pesticide costs and agricultural specialists' advice as the most important factors that they take into account when purchasing pesticides in the market. Fortyfour percent of farmers mentioned the pesticide dealer's advice as another factor that affects their choice of pesticides in the market. However, 22.5% of farmers stated that they are suspicious about the pesticide dealer's advice when purchasing pesticides. In many cases, pesticide dealers seem to be important in affecting farmer decisions in choosing pesticides. Others factors considered by farmers to a lesser degree when buying pesticides were neighbors' advice and the pesticide's safety.

Ownership of spraying equipment

Fifty-five percent of surveyed farmers owned spraying equipment, mostly backpacks, hand sprayers, and tractor pumps (Table D5.29). The distribution of sprayer ownership differed among the villages. Sprayer ownership among farmers is higher in Bestrove (73.5%) and Panaja (59.3%) than in other villages. One explanation for this difference may be the fact that grapes are very widespread in those two villages. As a result, the spraying equipment in these villages may be directly related to the chemical treatments on grapes rather than on olives. Of the 90 farmers that do not own any sprayer, 24.4% borrow from other farmers, 11.1% say the hired laborer provides the sprayer and 56% do not use a sprayer at all. Only a few farmers (2.2%) had rented sprayers.

5.2.5 Discussion and major findings

Farmers' knowledge on pests and their management

The survey found that farmers in Albania know very little about olive pests and their natural enemies. The olive fruit fly is the most widely known pest to farmers and is considered the most damaging olive pest. Farmers tend to be less knowledgeable about olive diseases than insects. They gave diverse responses regarding the nature of damage caused by olive pests. In many cases their descriptions of pest damages did not match those of the pests. Only a small number of farmers had any knowledge about natural enemies. Even those who responded mentioned only a few of natural enemies. There probably exists a diverse complex of natural enemies, but farmers do not know it.

The knowledge base with respect to olive pest management practices is also very limited. Farmers know about fertilization, irrigation, light and heavy pruning, but not much about methods for controlling olive pests and less so or not at all about IPM practices.

Information sources

Information on pest control methods is virtually nonexistent. Only a few farmers had participated in a training course on pest control for olives. Supporting structures such as agricultural research and extension have poor links with farmers. Most of the farmers had had limited contacts with extension specialists. Farmers do not have much faith in pesticide dealers' advice, but the latter is a major source of pesticide information nevertheless.

The main source of the pest management information farmers presently rely on is their own experience. IPM training courses on olive production systems may help farmers understand the olive pest and natural enemy biology, pest damage and the use of alternative control measures. Efforts should be made to strengthen the farmer-research-extension linkages by organizing farmer participatory training courses. Research scientists involved in IPM CRSP research should increase contacts with extension service specialists and work with them to insure that the olive IPM practices, developed by the IPM CRSP/Albania project, reach the farmers in the study area and beyond. Such a research-extension system has not existed in the past. The organization of field demonstrations with farmer groups coming from other regions and use of mass media may help in this direction.

Olives vs. Grapes

Olives receive very few pesticides, fertilizer, and other inputs. Only a small number of farmers use pesticides on olive trees. However, farmers do apply pesticide sprays and other inputs on grapes. Several factors may explain this different treatment of grapes versus olives. Olive trees normally exhibit biennial bearing, which serves as a disincentive to olive growers to use chemicals especially in years with low production. However, it may not be wise to question farmers' rationality regarding this point in the absence of economic data on justification of spraying in the off-year. Therefore more research is needed in this area. Unlike many other fruit trees, olives are very resistant to unfavorable agro-climatic conditions. Olives will give some yield even without spraying or any other inputs including fertilizer and irrigation, while grapes, are less likely to do so.

Olive grove fragmentation and pest management

The economic changes and structural reforms in Albanian agriculture have substantially affected pest control in olive groves. The process of fruit tree distribution in 1991 resulted in severe fragmentation of olive orchards. Consequently, fragmentation hindered the application of agricultural practices including pest management. Also it increased the cost of production by involving extra expenditure for chemical treatments, transportation, labor, and so forth.

The olive grove fragmentation and the lack of farmers' group action with respect to chemical treatment of olive trees has led to some negative spillover effects from pest infestation and reinfestation. That is, if one farmer sprays his own olive trees and other farmers do not spray trees in neighboring plots, the sprayed trees will be reinfested by olive pests coming from unsprayed trees[65]. Consequently, the farmer who sprays wastes money and gets no compensation for the harmful effects caused by other farmer actions (inaction). Private decision makers have limited incentives to include such hidden costs in their pest control decisions. One way to internalize such negative spillover effects may be the promotion of group action by farmers so that they can jointly spray olive trees. Another would be the consolidation of olive groves through redistribution of olive trees. However, the latter is easier said than done, because it is essentially a mini land reform and requires political support by various power structures within the villages and beyond. The limited application of pest management practices in olives is explained by other factors as well including limited financial means, unavailability of inputs in local markets, lack of price incentives and so forth.

IPM, pest mobility, and need for collective action

In addition to olive grove fragmentation, pest mobility is another factor that makes it difficult for individual farmers to manage the control of certain olive

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[65] Indeed, as noted earlier, farmers considered the case of these negative spillover effects as a strong reason for not using pesticides.

pests. Pests are not unique to a single farm and therefore pest control can be considered a communal problem (Knight & Norton, 1989; Lazarus & Dixon, 1984). Some of the mobile olive pests, like olive fruit fly, constitute a problem for the whole region because their movement may not be limited to adjacent fields and olive trees. Olive pest mobility suggests that the optimal pest control strategies must consider the possibilities for collective action within the olive growing region(s). Collective pest management strategies may offer additional advantages because of economies of scale in information gathering, processing and decision-making (Norgaard, 1976). The collective action may involve various groups including agrochemical industry, pesticide dealers, government institutions, NGO-s, and/or groups of farmers themselves (Knight & Norton, 1989).

Need for collective action by farmers is also closely related to the specifics of IPM. IPM constitutes a new paradigm in crop protection and involves the integrated use of a number of the pest control strategies. It is a concept and practice based in science and good business practice. IPM is more complex for the producer to implement than spraying by calendar. It requires skills in pest monitoring and understanding of insect bionomics and ecology. It involves cooperation among producers for effective implementation. But this cannot be done if farmers act alone and do not cooperate together and if the present stock of farmers’ knowledge on olive pest management practices is not improved and upgraded.

During the last eight years, group-actions by Albanian private farmers have generally been limited. The survey data showed that no respondent was a member of any farmer organization. This fact has great repercussions for the farming and agribusiness activities in the future including pest management practices in olives. Actually, Albanian farmers highly value their newly acquired status as being totally independent to run their everyday life. However, the promotion of farmer group action through the creation of farmers’ associations remains an imperative task in terms of olive IPM implementation. Public policies may be needed to provide incentives for collective action to control olive pests throughout the region.

Attitudes towards pesticide use

Farmers revealed little awareness of the potential harmful effects of pesticides on human health and the environment. Most farmers perceive that pesticide application leads to an increase of olive yields. However, the results of the survey showed that those who applied pesticides did not get higher yields. On the contrary, a small but significant negative relationship (correlation coefficient, $r = -.09$) was found between pesticide application in olives and olive yield. This result is consistent with a previous study carried out in The Philippines by Lazaro et.al. (1995). This negative relationship may be explained by a variety of reasons including pest resurgence, killing of predators, inappropriate use of pesticides, and so forth. Data also revealed that pesticide application in olives was positively related to pesticide application in grapes and citrus and to ownership of spraying equipment. The implication is that many of those farmers who sprayed other fruit trees, sprayed olives as well. Probably, those farmers used the same pesticides even though the pests of various fruit trees including olive trees are different and their control requires specific treatment. IPM participatory courses would help farmers recognize the potential negative effects of pesticide use on ground water, environment, and human health and show them how to take these potential effects into consideration in their pest management decisions.

Gender issues[66]

Women play an essential role in the agricultural sector in Albania. The results of the survey indicate that the knowledge gap between men and women regarding olive production systems is not wide and that women are involved in performing agricultural operations related to olives to the same extent as men are. The implication is that women must constitute an important target group in the training courses on olive pest management practices that might be organized in the future by the IPM CRSP/Albania project, extension service and/or other organizations. This is also necessary because many men work outside the country for at least part of the year.

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[66] See Table D5.30 and Daku et al. (2000).

Increase of pesticide use and need for IPM

Although pesticide use has recently dropped drastically due to the factors mentioned above as well as the weak economic position of farmers and the lack of functioning agricultural input markets, this situation will not last for long. As farmers' economic situations improve and the agricultural input markets consolidate, it is likely that farmers' ability to purchase off-farm inputs, including pesticides, will increase. Therefore, introduction of IPM practices to the olive sector in Albania is timely and appropriate and because most farmers' not currently using pesticides for controlling olive pests, it is an opportune time for implementing IPM programs. It has been shown that one of the serious obstacles to olive IPM implementation in developing countries is the growers' reliance on chemical treatments for controlling pests (Katsoyannos, 1992). Such reliance is not currently a major obstacle to adopting olive IPM practices in Albania. This finding is consistent with FAO's study on olive pests and their control in other countries of the Mediterranean region (Katsoyannos, 1992).

Section 5.3 Results of Farm-level Impact Assessment

5.3.1 Productivity and cost factors

Tables 5.31 and 5.32 present estimated costs and returns per hectare to produce olive oil in the study area based on three scenarios. As noted in Chapter 4, the three scenarios considered are: (i) a pesticide-based scenario that assumes the representative farmer applies calendar-based spraying for controlling olive pests as well as irrigation in addition to other cultivating practices; (ii) a minimum practice scenario in which the representative farmer applies limited spraying (20% of recommended sprayings), pruning (30% of the trees), manure and chemical fertilization (50% and 20% of recommended norms respectively), and no irrigation; and (iii) a do-nothing scenario that includes a limited application of manure fertilization and mowing tree middles only. The first two scenarios, that is, the pesticide-based and the minimum practice scenarios, were used as a baseline to examine the economic feasibility of olive IPM packages being developed by IPM CRSP/Albania Project. The pesticide-based scenario represents a situation that might become widespread in the years ahead once farmers can afford spraying olive trees. However, the minimum practice scenario shows the present situation of farmers in terms of olive pest management practices. Therefore, in order to show the impacts of the IPM CRSP research, it is significant to know, given where olive growers are now, what would be the impacts if they employed the IPM program. The estimated budgets also provide valuable information with regard

Table 5.31 Estimated costs and returns per hectare to produce olive oil in Vlora, Albania - 2001

Costs and Returns	Pesticide-based Scenario			Minimum-practice Scenario			Do-nothing Scenario		
	USD	Lek	%	USD	Lek	%	USD	Lek	%
Gross Returns									
Olives	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olive oil	1,182.86	165,600.00	100.00	655.71	91,800.00	100.00	218.57	30600.00	100.00
TOTAL GROSS RETURNS	**1,182.86**	**165,600.00**	**100.00**	**655.71**	**91,800.00**	**100.00**	**218.57**	**30,600.00**	**100.00**
Variable Costs									
Cultural:									
Mowing middles	42.86	6,000.00	4.15	21.43	3,000.00	4.22	21.43	3000.00	14.30
Pruning	68.57	9,600.00	6.65	20.57	2,880.00	4.05	0.00	0.00	0.00
Brush disposal	5.14	720.00	0.50	1.54	216.00	0.30	0.00	0.00	0.00
Irrigation	21.94	3,072.00	2.13	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer (N: 46-0-0)	89.49	12,528.00	8.67	17.90	2,505.60	3.52	0.00	0.00	0.00
Fertilizer (Manure)	48.86	6,840.00	4.74	24.43	3,420.00	4.81	24.43	3420.00	16.31
Pesticides	344.06	48,168.00	33.35	114.69	16,056.00	22.58	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal cultural	*620.91*	*86,928.00*	60.19	200.55	28,077.60	39.49	45.86	6420.00	30.61
Harvest:									
Labor - hand pick fruit	231.43	32,400.00	22.43	173.57	24,300.00	34.18	57.86	8100.00	38.62
Transport	13.71	1,920.00	1.33	10.29	1,440.00	2.03	3.43	480.00	2.29
Hired machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal harvest	*245.14*	*34,320.00*	23.76	183.86	25,740.00	36.20	61.29	8580.00	40.91
Processing:									
Transport	12.86	1,800.00	1.25	9.64	1,350.00	1.90	3.21	450.00	2.15
Press and process	137.14	19,200.00	13.29	102.86	14,400.00	20.25	34.29	4800.00	22.89
Bottling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	10.67	1,494.00	1.03	8.00	1,120.50	1.58	3.20	448.20	2.14
Subtotal processing	*160.67*	*22,494.00*	15.57	120.50	16,870.50	23.73	40.70	5698.20	27.17
TOTAL VARIABLE COSTS	**1,026.73**	**143,742.00**	99.52	**504.92**	**70,688.10**	99.43	**147.84**	**20698.20**	98.68
NET RETURNS ABOVE VARIABLE COSTS	**156.13**	**21,858.00**	15.13	**150.80**	**21,111.90**	29.69	**70.73**	**9901.80**	47.21
Fixed Costs									
Tractor/machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Property taxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land rent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olive tree rent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pruning tools	0.79	111.00	0.08	0.79	111.00	0.16	0.79	111.00	0.53
Spraying tools	0.94	132.00	0.09	0.94	132.00	0.19	0.00	0.00	0.00
Harvesting tools	1.18	165.00	0.11	1.18	165.00	0.23	1.18	165.00	0.79
Irrigation system	2.01	281.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Interests	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL FIXED COSTS	**4.92**	**689.00**	0.48	**2.91**	**408.00**	0.57	1.97	**276.00**	1.32
TOTAL COSTS	**1,031.65**	**144,431.00**	100.00	**507.83**	**71,096.10**	100.00	**149.82**	**20974.20**	100
NET RETURNS ABOVE TOTAL COSTS	**151.21**	**21,169.00**		**147.89**	**20,703.90**		**68.76**	**9625.80**	

Source: The cost data come from Table 4.9 in chapter 3 (p.154-155) and Table 5.32 which appears below.

Table 5.32 Estimated costs to produce olive oil in Vlora, Albania - 2001 (pesticide-based and minimum practice scenarios)

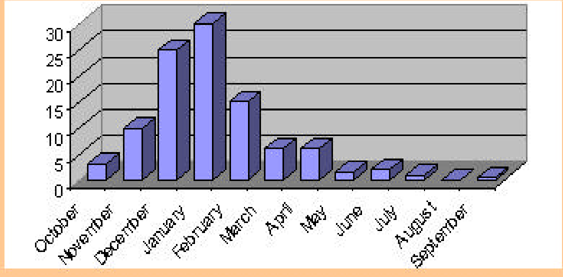
Operation		Cash and labor costs per olive tree (Lek)							Total cost per Ha (Lek)	
	Operation Time (hrs/tree)	hourly wage (Lek)	Labor cost/tree	Material/ tree	price/unit (Lek)	Material cost/tree	Fuel, Lube & repairs	Custom/ rent	Pesticide-based Scenario	Minimum practice Scenario
Cultural:										
Weed control - Mowing middles								50.00	6000.00	3000.00
Pruning and sucker	0.80	100.00	80.00						9600.00	2880.00
Brush disposal	0.10	60.00	6.00						720.00	216.00
Irrigation	0.26	60.00	15.60	1.00	10.00	10.00			3072.00	0.00
Fertilizer (manure)	0.20	60.00	12.00	20.00	2.00	40.00		5.00	6840.00	3420.00
Fertilizer (nitrogen)	0.04	60.00	2.40	0.50	200.00	100.00		2.00	12528.00	2505.60
Pest control - pesticides	1.04		68.04			275.04	58.32		48168.00	16056.00
Total cultural costs	**2.44**		**184.04**			**425.04**	**58.32**	**57.00**	**86928.00**	**28077.60**
Harvest:										
Hand pick fruit	2.70	100.00	270.00						32400.00	24300.00
Transport			0.00			0.00	16.00		1920.00	1440.00
Total harvest costs	**2.70**	**100.00**	**270.00**			**0.00**	**16.00**		**34320.00**	**25740.00**
Processing:										
Press and process			0.00			0.00		160.00	19200.00	14400.00
Transport			0.00			0.00	15.00		1800.00	1350.00
Miscellaneous	0.15	60.00	9.00			0.00	3.45		1494.00	1120.50
Total processing costs	**0.15**		**9.00**			**0.00**	**18.45**	**160.00**	**22494.00**	**16870.50**
Capital recovery costs:	**Price** (lek/unit)	**Years** life	**Salvage** value (lek)	**Interest** rate (%)	**Economic** depreciation	**Opportunity** cost	**Capital** Recovery	**Adjusted** CRC		
Pruning tools	2,500.00	10.00	0.00	6.00	250.00	82.50	332.50	110.83	111.00	111.00
Spraying tools	4,000.00	15.00	0.00	6.00	266.67	128.00	394.67	131.56	132.00	132.00
Harvesting nets	500.00	5.00	0.00	6.00	100.00	18.00	118.00	118.00	118.00	118.00
Buskets	200.00	5.00	0.00	6.00	40.00	7.20	47.20	47.00	47.00	47.00
Irrigation system	10,000.00	40.00	1,000.00	6.00	225.00	336.75	561.75	280.88	281.00	0.00
Total Fixed Costs									689.00	408.00
TOTAL COSTS	**5.29**		**463.04**			**425.04**	**92.77**	**217.00**	**144431.00**	**71096.10**

Source: The cost data come from Table 4.9 in chapter 3 (p.154-155) and assumptions made in Chapter 3 (p.147-153).

to olive cost structure as well as the productivity and costs factors. Taking into account the past trends of olive yields in the study area and the effects of biennial bearing, an average annual yield of 552 kg oil per ha was used for the first scenario and three quarters and a quarter of that yield were assumed for the minimum practice and do-nothing scenarios, respectively[67].

Referring to the budget figures for the pesticide-based scenario in Table 5.31, variable costs represent 99.5% of the total costs and the reminder are fixed costs. The structure of variable costs is as follows: cultural practices 60.2%, harvesting 23.8%, and processing 16%. Among the cultural practices, pesticides rank first accounting for nearly 34% of total costs, followed by fertilization 13.4%, pruning 7.15%, mowing middles 4.15%, and irrigation 2.13%[68]. The traditional olive cultivation in Albania is labor intensive. Labor represents nearly 50% of production costs (Table 5.32). The estimated total number of working hours required for olive cultivation in the study area is 635 hours/ha/year, of which 324 hrs/ha/year (51%) are needed for harvesting. As a result, the cost of labor absorbs nearly half the value of marketable production. In countries with intensive olive groves the number of working hours ranges between 204 and 380 hours/ha/yr (Katsoyannos, 1992). Labor requirements are concentrated over a limited period of time between late November and early April (Table 5.33).

Table 5.33: Labor Requirements in the olive orchards in Albania (hours/ha)

Operations	Cultivation	Fertilization	Pruning	Hoeing	Spraying	Harvesting	Transport	Total	%
October								19	3.0
November								63	10.0
December								159	25.0
January								190	30.0
February								95	15.0
March								38	6.0
April								38	6.0
May								10	1.5
June								13	2.0
July								6	1.0
August								0	0.0
September								3	0.5
Total	31.2	28.8	96	12	124.8	324	18	635	
%	4.9	4.5	15.1	1.9	19.7	51.0	2.8		

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[67] See sections 4.4 and 4.6 in chapter 4.

[68] Cost of irrigation includes water and labor expenditures associated with irrigation assuming that irrigation water is available.

This characteristic of olive growing presents a serious problem in terms of labor shortages during harvesting as well as seasonal unemployment for olive growers. As Figure 5.7 shows, harvesting, spraying, and pruning are the operations that require the highest input of labor.

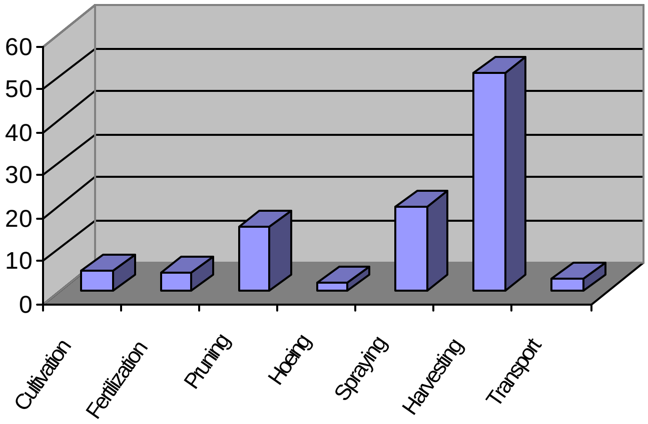

Figure 5.7 The estimated labor requirements (%) by operation in olive orchards in Albania

In the pesticide-based scenario, growers spend an average of 144,431 lek/ha, receive 165,600 lek as gross returns resulting in a positive net return to management (above total costs) of 21,169 lek per ha or $151.21/ha (Table 5.31). Similar results are generated even from the minimum practice scenario in which an average grower spends 71,096 lek/ha, receives 91,800 lek/ha as gross returns resulting in 20,704 lek/ha as net returns. Positive net returns result for the do-nothing scenarios as well, however the net returns are much lower than those of the other two senarios. For example, growers that follow do-nothing scenario spend 20,974 lek /ha and receive 30,600 lek/ha gross revenue, resulting in 9,625 lek/ha net returns, which are less than half the net returns achieved in the minimum practice scenario.

5.3.2 Profitability of alternative IPM practices

Table 5.34 presents a summary of the results of partial budget analysis of alternative olive IPM strategies, which uses as baseline the *pesticide-based scenario*. These alternative IPM strategies are evaluated to determine which ones are economically feasible in terms of yield and quality gains and/or savings with respect to a reduction in pesticide use or other inputs if any. The most likely values of gross yield and quality gains (price increase) elicited from experts for each experiment were multiplied by the probability of research success. In order to perform the sensitivity analysis of the results, the minimum and maximum values of expected yield and quality gains were considered as well. Detailed partial budgets developed for each experiment are given in tables 5.35-5.41 (see below).

Table 5.34 Estimates of farm-level profitability of olive IPM practices - pesticide-based scenario (Lek/Ha)

Partial budget items		Experiments						
		Exp 1	Exp 2	Exp 2/1	Exp 3	Exp 4	Exp 5	Exp 6
Minimum Yield Gain (%)		11.00	13.00	5.00	16.00	12.00	12.00	22.00
Maximum Yield Gain (%)		28.00	29.00	5.00	34.00	23.00	25.00	55.00
Minimum Price Gain (%)		6.00	5.00	0.00	0.00	9.00	0.00	0.00
Maximum Price Gain (%)		15.00	11.00	0.00	0.00	16.00	0.00	0.00
Adjusted Gross Yield Gain (%)		13.10	13.10	5.00	14.20	17.30	13.40	37.30
Adjusted Gross Price Gain (%)		8.00	4.00	0.00	0.00	11.00	0.00	0.00
Added Revenue:								
	Minimum (Lek)	28,152	28,318	8,280	23,515	34,776	19,872	36,432
	Maximum (Lek)	71,208	66,240	8,280	56,304	64,584	41,400	91,080
	Adjusted (Lek)	34,942	28,318	8,220	23,515	46,865	22,190	61,769
Reduced Costs (Lek)		11,100	13,968	0.00	11,676	7,560	0.00	0.00
TOTAL ADDED BENEFITS:								
	Minimum (Lek)	39,252	43,776	8,280	38,172	42,336	19,872	36,432
	Maximum (Lek)	82,308	80,208	8,280	67,980	72,144	41,400	91,080
	Adjusted (Lek)	46,042	42,286	8,280	35,191	54,425	22,190	61,769
Added Costs (Lek)		0.00	13,554	1,440	5,000	17,040	9,770	3,353
Reduced Revenue (Lek)		0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ADDED COSTS		0.00	13,554	1,440	5,000	17,040	9,770	3,353
NET REVENUE:								
	Minimum (Lek)	39,252	10,794	6,840	33,172	32,736	10,102	33,079
	Maximum (Lek)	82,308	47,226	6,840	62,980	62,544	31,630	87,727
	Adjusted (Lek)	46,042	28,732	6,840	30,191	37,385	12,421	58,416

Exp. 1 = Harvest timing and olive fly control; Exp. 2 = Vegetation management; Exp. 3 = Pruning and copper treatment

Exp. 4 = Pheromones and olive fly; Exp. 5 = Harvesting methods; Exp. 6 = Irrigation

The analysis of the harvest timing experiment indicated that if this practice were to be adopted by farmers, on the average, it would provide added net benefits of 46,042 Lek per hectare (Table 5.35). These added income are derived from an expected yield and quality gain of 13% and 8% respectively as well as from savings related to cost of labor and reduction in pesticides use due to adopting an optimal harvest timing, which eliminates the need for an additional spraying. The preliminary experiment results show the last week of

October to be an optimal harvest time for the Frantoi cultivar. The percentage of olive fruit fly infestation during this period is lower compared with other treatments that refer to later times of harvest.

The preliminary results of vegetation management experiment revealed that straw mulching (T7) provides adequate weed control compared to the herbicide treatments. Straw mulching was found to increase yields, avoid weed competition, and conserve soil moisture for longer times than other treatments. Good results were also obtained using the selective herbicide Diuron. The partial budget analysis of straw mulching found that this alternative weed management strategy, if adopted by farmers, would result in an added net benefit of 28,732 lek per hectare (Table 5.36). This benefit comes from yield increase and quality improvement as well as from savings related to herbicide application and labor of applicator. However, growers who adopt this practice are expected to incur some additional material and labor costs related to straw mulching.

Another component of this experiment, which is not related to vegetation management, is the use of *Bacillus Thuringiensis* (BT) as an alternative strategy to spraying with BI 58 (Dimethoate) for controlling olive moth. The preliminary experimental results showed that the percentage of olive moth larval mortality did not differ significantly between the treatments with BT and BI 58. However, the number of natural enemies was much higher in the plots treated with BT than in plots treated with BI 58. The partial budget indicated that this alternative strategy, if adopted by olive growers, would give an added net benefit of 6,840 lek per hectare compared to those farmers who spray olives with BI 58 (Table 5.37). This benefit comes from yield increases. Added revenue from the yield increase is offset somewhat by the cost of the BT solution, which was higher than that of BI 58.

The experiments on effects of pruning and timing of copper sprays for controlling blacks scale, leaf spot and olive knot have not shown clear comparative results so far. However, some data revealed that the black scale infestation was reduced and spray penetration was improved by pruning trees. Also, preliminary results showed that copper treatments applied in March and April are more protective than those in other times of the year. Partial budget analysis indicated that pruning and the optimal application of copper result in net added benefits of 30,191 lek per hectare (Table 5.38). These added benefits arise from an increase in yield as well as a reduction in the number of copper sprayings. Some added costs are incurred with respect to pruning tools and additional labor hours need for pruning.

Table 5.35 Harvest timing vs Dimethoate (40%) - pesticide-based scenario

		LEK	USD	
Added benefits				
Added revenue		34942	250	Derived from more yield, quality
	Yield gain	21694	155.0	improvement, cost and labor savings
	Quality gain	13248	94.6	
Reduced cost		11100	79.3	
	Insecticide use	7200	51.4	
	labour of applicator	3900	27.9	
Total Added Benefits		46042	329	
Added costs				
Added cost				
		0	0.0	
Reduced revenue				
		0	0.0	
Total Added Cost		0	0.0	
Net Added Benefits		46042	329	

Table 5.36 Straw mulching, plowing, and cover crop vs Diuron (50%) and Glyphosate (36%) - pesticide-based scenario

		LEK	USD	
Added benefits				
Added revenue		28318	202	Derived from more yield, quality
	Yield gain	21694	155.0	improvement, cost and labor savings
	Quality gain	6624	47.3	
Reduced cost		13968	99.8	
	Insecticide use	12096	86.4	
	labour of applicator	1872	13.4	
Total Added Benefits		42286	302	
Added costs				
Added cost		13554	96.8	
	Materials	7500	53.6	Material cost and labor used
	Labor	4554	32.5	in the intervention
	Fuel and lube	1500	10.7	
Reduced revenue				
		0	0.0	
Total Added Cost		13554	96.8	
Net Added Benefits		28732	205	

Note: Yield and quality gain estimates are adjusted using the probability of research success

Table 5.37 Bacillus Thuringencies (BT) vs Dimethoate (40%) - pesticide-based scenario

		LEK	USD		
Added benefits		LEK	USD		
Added revenue		8280	59		Derived from more yield
	Yield gain	8280	59.1		
	Quality gain				
Reduced cost		0	0.0		
Total Added Benefits		8280	59		
Added costs					
Added cost		1440	10.3		Material cost and labor used
	Insecticide use	1440	10.3		in the intervention
	labour of applicator	0	0.0		
Reduced revenue					
		0	0.0		
Total Added Cost		1440	10.3		
Net Added Benefits		6840	49		

Table 5.38 Pruning and optimal timing of copper spray vs copper sprays only - pesticide scenario

Added benefits		LEK	USD		
Added revenue		23515	168		Derived from more yield, quality
	Yield gain	23515.2	168.0		improvement, cost and labor savings
	Quality gain	0.0	0.0		
Reduced cost		11676	83.4		
	Insecticide use	7776	55.5		
	labour of applicator	3900	27.9		
Total Added Benefits		35191	251		
Added costs					
Added cost		5000	35.7		Material and labor costs
	Pruning tools and labor	5000	35.7		
Reduced revenue					
		0	0.0		
Total Added Cost		5000	35.7		
Net Added Benefits		30191	216		

Data obtained so far from the pheromone experiment showed that olive fruit fly infestation was low in the first two generations in both plots treated with Eco Traps (T1) and untreated plot (T2) during the period June-September. However, starting early in October, the third generation of olive fruit fly population increases and therefore high level of fruit infestation was observed. At harvest time (early November), in groves treated with Eco Trap, only 5-6% of the olive fruits were infested. By contrast, in olive groves sprayed with dimethoate, the olive fruit fly infestation reached about 20%. Partial budget analysis for this experiment indicated that the pheromone-based strategy for controlling olive fruit fly, if adopted by growers, would result in net added benefits of 37,385 lek per hectare compared to chemical treatment (Table 5.39). This additional benefit would be realized from yield increase and quality improvement. The cost of Eco Trap is 25% higher than the cost of chemical treatment. However, application of pheromone-based strategy for controlling

Table 5.39 Pheromone vs Dimethoate (40%) - pesticide-based scenario

Added benefits		LEK	USD		
Added revenue		46865	335		
	Yield gain	28649	204.6		Derived from more yield, quality
	Quality gain	18216	130.1		improvement, and labor saving
Reduced cost		7560	54.0		
	Insecticide use	7560	54.0		
	labour of applicator	0.0	0.0		
Total Added Benefits		54425	388.7		
Added costs					
Added cost		17040	121.7		
	Insecticide use	16800	120.0		Material cost used in the intervention
	labour of applicator	240.0	1.7		
Reduced revenue					
		0.0	0.0		
Total Added Cost		17040	121.7		
Net Added Benefits		37385	267		

Table 5.40 "Milking" vs "Beating" harvesting method - pesticide scenario

Added benefits		LEK	USD		
Added revenue		22190	159		
	Yield gain	22190	158.5		Derived from more yield and quality
	Quality gain	0	0.0		improvement
Reduced cost					
		0	0.0		
Total Added Benefits		22190	159		
Added costs					
Added cost		9770	70		
	Harvesting tools	49.5	0.4		Material cost and labor used
	labor	9720	69.4		in the intervention
Reduced revenue					
		0	0.0		
Total Added Cost		9769.5	69.8		
Net Added Benefits		12421	89		

olive fruit fly reduces the number of sprayings and therefore is associated with additional health and environmental benefits to the farmers and society as a whole.

The harvesting methods and irrigation experiments were included in the evaluation exercise on the premise that these might offer great potential for increasing olive productivity and reducing the pest infestation[69]. At present, these are tentative themes and efforts were made to come up with approximate figures on their potential benefits to the farmers who adopt them once these technology packages become available. The partial budget for the "milking" method of harvesting showed that, if adopted, this method gives an added benefit of 22,190 lek per hectare due to a yield increase. However, additional expenses of 9,770 lek per hectare are incurred from buying harvesting tools and the labor associated with application of this method. The potential net added benefit for this harvesting method is 12,421 lek per hectare (Table 5.40 above). The application of irrigation promises great productivity potential if adopted by farmers. Use of irrigation leads to a 37% increase in yields, which translated in terms of revenue, implies added revenue of 61,769 lek per hectare. Farmers who adopt irrigation would also incur added costs of 3,353 lek per hectare. The difference between added revenue and added costs for this experiment results in net added benefit of 58,416 lek per hectare (table 5.41).

Table 5.41 Irrigation vs no irrigation - pesticide-based scenario

Added benefits		LEK	USD				
Added revenue		61,769	441.2				
	Yield gain	61,769	441.2		Derived from more yield and		
	Quality gain	0.0	0.0		quality improvement		
Reduced cost							
		0.0	0.0				
Total Added Benefits		61,769	441.2				
Added costs							
Added cost		3,353	24.0				
	Labor	1,872	13.4		Material cost and labor used		
	Irrigation water	1,200	8.6		in the intervention as well as		
	Irrigation system	281	2.0		additional costs for irrigation		
					system		
Reduced revenue							
		0.0	0.0				
Total Added Cost		3,353	24.0				
Net Added Benefits		58,416	417.3				

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[69] Effect of irrigation on pest infestation is unclear. Sometimes, it makes olive fly infestation worse.

However, this study assumes that irrigation water is available in the olive growing areas. A sensitivity analysis of the added benefits for the baseline pesticide-based scenario was run based on the possible minimum and maximum values of yield and price gains elicited from the expert interviews. The sensitivity analysis showed that the potential profitability varies between 39,252 and 82,308 lek/ha for experiment 1, 10,794 and 47,226 lek/ha for experiment 2, 33,172 and 62,980 lek/ha for experiment 3, and 32,736 and 62,544 lek/ha for experiment 4. These results imply that the olive IPM packages are expected to be economically feasible even when the net returns are obtained using the most pessimistic estimates of yield and quality gains.

Table 5.42 presents a summary of the results of partial budget analysis of alternative olive IPM strategies, which is performed using as baseline the *minimum practice scenario*. Tables D5.43-D5.48, which provide detailed partial budgets constructed for each IPM strategy for this scenario, appear in appendix D. Under the minimum practice scenario, it is assumed that farmers will move

Table 5.42 Estimates of farm-level profitability of olive IPM practices - minimum practice scenario

Partial budget items		Experiments					
		Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
Minimum Yield Gain (%)		11.00	13.00	16.00	12.00	12.00	22.00
Maximum Yield Gain (%)		28.00	29.00	34.00	23.00	25.00	55.00
Minimum Price Gain (%)		6.00	5.00	0.00	9.00	0.00	0.00
Maximum Price Gain (%)		15.00	11.00	0.00	16.00	0.00	0.00
Adjusted Gross Yield Gain (%)		13.10	13.10	14.20	17.30	13.40	37.30
Adjusted Gross Price Gain (%)		8.00	4.00	0.00	11.00	0.00	0.00
Added Revenue:							
	Minimum (Lek)	21,114	26,082	19,872	26,082	14,904	27,324
	Maximum (Lek)	53,406	49,680	42,228	48,438	31,050	68,310
	Adjusted (Lek)	26,206	21,238	17,636	35,149	16,643	46,327
Reduced Costs (Lek)		2,220	2,794	0	4,584	0.00	0.00
TOTAL ADDED BENEFITS:							
	Minimum (Lek)	23,334	28,876	19,872	30,666	14,904	27,324
	Maximum (Lek)	55,626	52,474	42,228	53,022	31,050	68,310
	Adjusted (Lek)	28,426	24,032	17,636	39,733	16,643	46,327
Added Costs (Lek)		0.00	9,876	9,841	17,040	9,770	3,353
Reduced Revenue (Lek)		0.00	0.00	0.00	0.00	0.00	0.00
TOTAL ADDED COSTS		0.00	13,554	9,841	17,040	9,770	3,353
NET REVENUE:							
	Minimum (Lek)	23,334	4,024	10,031	13,626	5,135	23,971
	Maximum (Lek)	55,626	9,202	22,387	35,982	21,281	64,957
	Adjusted (Lek)	28,426	10,478	7,796	22,693	6,873	42,974

Exp. 1 = Harvest timing and olive fly control; Exp. 2 = Vegetation management; Exp. 3 = Pruning and copper treatment

Exp. 4 = Pheromones and olive fly; Exp. 5 = Harvesting methods; Exp. 6 = Irrigation directly from an olive production system with limited use of pesticides into an IPM program, rather than a full pesticide program, given the IPM CRSP research activities. Referring to Table 5.42, the partial budget analysis indicates that even under this scenario, all olive IPM packages being developed by IPM CRSP are expected to be profitable to growers that would adopt them. Growers who would adopt this IPM packages are expected to receive in net benefits 28,426 lek/ha from harvest timing practice, 10,478 lek/ha from vegetation management practice, 7,796 lek/ha from the pruning and timing of copper spray package, 22,693 lek/ha from use of pheromone for controlling olive fruit fly, 6,873 lek/ha from “milking” harvesting method, and 42,974 lek/ha from irrigation. Note that potential adopters under this scenario are expected to incur additional costs as compared to the group of adopters who move from pesticide-based system to olive IPM program. For example, producers who presently use very little pesticide for controlling olive pests and are willing to adopt vegetation management practice would have to incur additional cost (13,554 lek/ha) that are similar to those producers who move from pesticide-based pest control system to IPM system. However, the reduction in cost associated with this IPM practice for the latter is nearly five times higher than for the former group of farmers.

5.3.3 Major findings

The results of partial budget analysis of alternative olive IPM practices indicated that all of the proposed IPM packages are economically feasible under the two scenarios considered. These IPM packages promise positive net benefits and are more profitable than both the current farmer practices involving limited spraying of olive trees and the pesticide-based pest control practices which at present are not widespread but are expected to become so in the near future (Figure 5.8). Among the experiments that are underway, the harvest timing experiment is expected to generate the largest net benefits per hectare followed by pheromones experiment, the pruning and timing of copper spray experiment, and the vegetation management experiment.

Although each alternative package has the potential for higher yields and improved product quality due to reduced crop loss from pests, some of them also incur additional costs. Particularly, for the vegetation management (Exp. 2) and pheromone experiment (Exp. 4), farmers willing to adopt these packages need some extra financial resources to buy inputs that may not be available at the farm level. For example, farmers who would purchase pheromones for controlling olive fruit fly might encounter not only a financial burden, but also unavailability of such pheromones at local markets. In addition to olive growers, these alternative practices should benefit human health and environment.

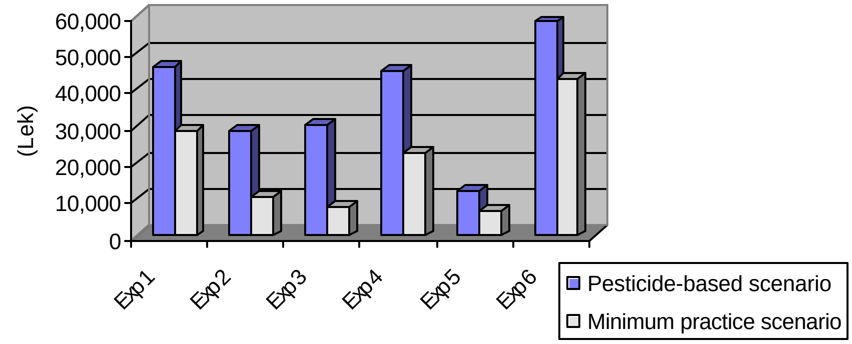

Figure 5.8 Net added benefits of alternative olive IPM practices (pesticide-based scenario vs. minimum practice scenario)

Exp. 1 = Harvest timing and olive fly control; Exp. 2 = Vegetation management; Exp. 3 = Pruning and copper treatment
Exp. 4 = Pheromones and olive fly; Exp. 5 = Harvesting methods; Exp. 6 = Irrigation

As figure 5.8 shows, the net benefits that each IPM package would generate under the minimum practice scenario are relatively lower than those under pesticide based scenario. This difference in potential net benefits between the two scenarios is attributed to two factors. First, farmers who move directly from a limited use of pesticides or no sprays at all to IPM packages are presumed to start from a lower base in terms of olive yields and production compared to those who apply calendar-based spraying for olive trees. Second, while the costs that are expected to be incurred from adopting any of the proposed IPM packages are more or less of the same magnitude for both groups of farmers described above, this is not the case for the level of cost reduction. Farmers who use limited sprayings get relatively less reduction in costs associated with pesticides and other inputs. Therefore, the added revenues resulting from adopting an IPM practice for this group of farmers are offset somewhat by the relatively lower reduction in costs as compared to farmers who move from pesticide-based practices to IPM.

Section 5.4 Results of Market-level Impact Assessment

This section presents results of various simulations designed to evaluate the potential market-level economic impacts (benefits to producers, consumers, and the country as a whole) from IPM research on olives. Based on the economic surplus equilibrium displacement model for the Albanian olive market developed in Chapter 3, the prices, quantities, and present value of economic surpluses were simulated for each experiment across olive producing zones and for each scenario of interest. The section proceeds as follows: first, it presents technology generation and adoption parameters of olive IPM research elicited from the expert survey as well as the baseline market conditions; second, the simulation process followed for computing economic surplus measures is described step by step; third, the evaluation results for each experiment and across zones are presented; and finally, the aggregate measures for the whole IPM research program are discussed.

5.4.1 Technology generation and adoption parameters

Table 5.49 presents the technology generation and expected adoption parameters of olive IPM research as elicited from the expert survey. These figures represent the averages of the individual responses given by experts interviewed. The table shows the expected percentage of yield gains and expected increase in price of olive oil due to IPM research-induced improvement in quality. Adoption parameters include dissemination thresholds, time to develop IPM packages, ceiling level of adoption, number of years to maximum adoption, number of years before disadoption and to complete disadoption if any. Specific technology and adoption parameters were derived for each experiment and olive growing zone because different zones have different agro-ecological conditions and farmers' adoption of IPM practices might vary across zones. Additionally, probability of research success was computed using data on predicted research outcomes and the dissemination thresholds for each experiment and zone.

The predicted yield and quality gains were assumed to follow a triangular distribution and therefore these were specified in terms of minimum, most likely, and maximum possible outcomes. It is also assumed that all four IPM experiments underway in Albania as well as the two potential experiments generate yield gains. However, the group of experts interviewed indicated that only three experiments (Exp. 1, 2, 4) might lead to quality improvements. For example, harvesting timing experiment is expected to generate significant yield gains that vary from a minimum gain of 11%, a most likely gain of 17%, and a maximum gain of 28% in Zone 1. Similarly, the same experiment promises improvement in quality of olive oil, which translated in price increase implies a minimum gain of 8%, a most likely gain of 12%, and a maximum gain of 15% in Zone 1.

Table 5.49 Technology generation and adoption parameters of olive IPM research (Expert Survey)

	The expected percentage of YIELD GAIN								
Experiments	With research			Without research					
Zones				With Pesticides			Without pesticides		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Experiment 1									
Zone 1	11	17	28	3	5	6	2	3	4
Zone 2	8	13	22	2	4	5	2	3	4
Zone 3	7	14	18	1	3	4	1	2	3
Experiment 2									
Zone 1	13	21	29	2	5	8	2	4	5
Zone 2	9	17	20	2	4	7	1	2	3
Zone 3	10	15	18	3	5	6	1	2	3
Experiment 3									
Zone 1	16	27	34	2	4	6	3	4	5
Zone 2	13	19	26	1	2	4	2	3	4
Zone 3	10	14	21	1	3	5	1	2	3
Experiment 4									
Zone 1	12	17	23	2	5	8	2	3	5
Zone 2	8	13	18	1	3	7	2	3	4
Zone 3	6	12	17	2	5	6	1	2	3
Experiment 5									
Zone 1	12	18	25	0	0	0	0	0	0
Zone 2	12	16	21	0	0	0	0	0	0
Zone 3	10	16	20	0	0	0	0	0	0
Experiment 6									
Zone 1	22	35	55	0	0	0	0	0	0
Zone 2	18	28	45	0	0	0	0	0	0
Zone 3	12	29	37	0	0	0	0	0	0

Generally speaking, the elicited yield and price gains in the non-target zones (Zone 2, 3) tend to be less than those in the research target zone (Zone 1) on the premise that these are research spillover effects that might not have the same magnitude as in the research target zone.

The elicited maximum adoption rates for olive IPM practices varied between 25% and 40% in Zone 1, 18% and 33% in Zone 2, and 10% and 20 % in Zone 3. Higher adoption rates were predicted for harvest timing experiment (Exp. 1), pruning and cooper treatment experiment (Exp. 3), and harvesting methods experiment (Exp. 5). However, experts expect relatively low adoption rates for pheromone experiment (Exp. 4) and irrigation experiment (Exp. 6). Such differentiated adoption rates are explained by the assumptions that various experiments might require additional labor and capital investments. Furthermore, producers' perceptions of technology risk with respect to certain IPM practices might vary among various groups of farmers with different access to resources, information and IPM training. According to expert opinions, the IPM packages to be generated from Experiments 1 and 3 are not expected to

Table 5.49 (continued...)

Expected increase in PRICE of olive oil due to quality improvement (%)			Dissemination threshold (%)	Time to develop olive IPM Techniques (years)	Ceiling level of Adoption (%)	Number of years to maximum adoption	Number of years before disadoption	Number of years to complete disadoption
Minimum	Most likely	Maximum						
8	12	15	17	4	40	6	na	na
5	8	12	12	4	30	10	na	na
5	7	11	12	4	20	10	na	na
5	8	11	20	5	35	8	12	8
3	6	8	15	5	30	8	12	6
3	5	7	15	5	15	10	10	6
0	0	0	26	5	35	8	na	na
0	0	0	19	5	30	10	na	na
0	0	0	15	5	20	10	na	na
9	12	16	15	5	30	10	10	7
7	10	13	12	5	25	12	10	7
6	9	12	11	5	12	12	12	7
0	0	0	17	10	40	7	8	8
0	0	0	16	10	33	9	9	7
0	0	0	16	10	20	10	9	7
0	0	0	30	10	25	10	na	na
0	0	0	24	10	18	12	na	na
0	0	0	23	10	10	12	na	na

become obsolete within the 30 year planning horizon used in this study. Time to develop IPM packages is expected to take 4-5 years for Experiments 1-4 that are currently under way and up to 10 years for the two potential experiments. However, the time to maximum adoption varied from 6 to 12 years.

As explained in Chapter 4, three scenarios were used in the evaluation exercise. The first two scenarios represent an extrapolation of the present "without" IPM research situation, which is further disaggregated into "with" and "without" pesticide use for controlling olive pests. The third scenario considers the "with" IPM research situation. It is assumed that the first two baseline scenarios involved some yield gains during the thirty years of the planning horizon. Presumably, this potential yield gain is related to the better overall management practices and a growing interest of farmers in olives considering it as a cash crop over time. However, any future quality improvement of olive products in these two baseline scenarios is ruled out. Thus, the without research/without pesticide scenario (hereinafter referred to as minimum practice scenario) and the without research/with pesticide scenario (hereinafter referred to as pesticide-based scenario) are used as base scenarios. All simulations with respect to "with" IPM research scenario involving research-induced supply and demand shifts are conducted relative to these two different baselines. That is, the predicted changes in prices, quantities, gross values of olive oil production, total benefits, and economic surpluses accruing to producers and consumers, all are expressed relative to these two different bases. The impacts of IPM CRSP research activities on olives in Albania were simulated over a 30 year period using a discount rate of 6%.

Tables 5.50 and 5.51 report the basic data used to define the baseline simulations. These tables include base number of trees, yields, quantities of olive oil produced, and average price of olive oil for each district and producing zones for the two baseline scenarios. Due to lack of sufficient data on olive product prices and yields, this study assumes the same prices and yields for both research target zone and non-target zones.

Table 5.50 The baseline olive oil production (Q_0) and prices (P_0) across producing zones (pesticide-based scenario)

ZONES	No. of trees in production	Yield kg/ tree	Yield kg oil/ tree	Oil Production (Qo) (kg)	Oil Production (Qo) (Ton)	Initial Price (Po) (lek/kg oil)	Initial Price (Po) (USD/Ton oil)
Sarande	417,000	20.00	4.60	1,918,200	1,918.20	300.00	2,142.86
Vlore	624,000	20.00	4.60	2,870,400	2,870.40	300.00	2,142.86
Zone 1	1,041,000	20.00	4.60	4,788,600	4,788.60	300.00	2,142.86
Berat	531,000	20.00	4.60	2,442,600	2,442.60	300.00	2,142.86
Fier	517,000	20.00	4.60	2,378,200	2,378.20	300.00	2,142.86
Lushnje	233,000	20.00	4.60	1,071,800	1,071.80	300.00	2,142.86
Durres	169,000	20.00	4.60	777,400	777.40	300.00	2,142.86
Tirane	286,000	20.00	4.60	1,315,600	1,315.60	300.00	2,142.86
Zone 2	1,736,000	20.00	4.60	7,985,600	7,985.60	300.00	2,142.86
Tepelene	69,000	20.00	4.60	317,400	317.40	300.00	2,142.86
Elbasan	276,000	20.00	4.60	1,269,600	1,269.60	300.00	2,142.86
Kruje	113,000	20.00	4.60	519,800	519.80	300.00	2,142.86
Lezhe	15,000	20.00	4.60	69,000	69.00	300.00	2,142.86
Shkoder	55,000	20.00	4.60	253,000	253.00	300.00	2,142.86
Zone 3	528,000	20.00	4.60	2,428,800	2,428.80	300.00	2,142.86
Total	3,305,000	20.00	4.60	15,203,000	15,203.00	300.00	2,142.86

Sources: AUT, 1987; MOAF, 2000; own calculations.

Table 5.51 The baseline olive oil production (Q0) and price (P0) by target zones (minimum practice scenario)

ZONES	No. of trees in production	Yield kg/ tree	Yield kg oil/ tree	Oil Production (Qo) (kg)	Oil Production (Qo) (Ton)	Initial Price (Po) (lek/kg oil)	Initial Price (Po) (USD/Ton oil)
Sarande	417,000	15	3	1,438,650	1,439	300	2,143
Vlore	624,000	15	3	2,152,800	2,153	300	2,143
Zone 1	1,041,000	15	3	3,591,450	3,591	300	2,143
Berat	531,000	15	3	1,831,950	1,832	300	2,143
Fier	517,000	15	3	1,783,650	1,784	300	2,143
Lushnje	233,000	15	3	803,850	804	300	2,143
Durres	169,000	15	3	583,050	583	300	2,143
Tirane	286,000	15	3	986,700	987	300	2,143
Zone 2	1,736,000	15	3	5,989,200	5,989	300	2,143
Tepelene	69,000	15	3	238,050	238	300	2,143
Elbasan	276,000	15	3	952,200	952	300	2,143
Kruje	113,000	15	3	389,850	390	300	2,143
Lezhe	15,000	15	3	51,750	52	300	2,143
Shkoder	55,000	15	3	189,750	190	300	2,143
Zone 3	528,000	15	3	1,821,600	1,822	300	2,143
Total	3,305,000	15	3	11,402,250	11,402	300	2,143

Sources: AUT, 1987; MOAF, 2000; own calculations.

5.4.2 Simulation process

The procedures followed for conducting simulation to estimate changes in economic surplus measures due to IPM research-induced shifts in olive supply and demand are described through tables 5.52-5.59. In fact, these tables represent simulations conducted to measure the impacts from research-induced yield gains for experiment 1 using as a baseline the full pesticide program and are chosen for illustration purposes only[70]. The simulation process for estimating the welfare changes due to shift in supply involved the following steps:

Step 1: Calculating probability of research success and adjusting gross yield gains. The first block in table 5.52 shows the steps that were followed to adjust the elicited gross yield gains. Based on the minimum, most likely, and maximum possible yield gains, the dissemination thresholds, and the formulas 4.6-4.9 given in Chapter 4, the following two measures were computed: (i) probability of research success and (ii) the conditional gross yield gains. Next, the computed conditional gross yield gains were multiplied by the probability of research success to derive the adjusted gross yield gains. The second block in this table indicates some of the computing components of formulas 4.6-4.9.

Step 2: Translating gross yield gains into net yield gains. Table 5.53 illustrates the use of partial olive budgets to translate the gross yield gains and associated additional input costs, if any[71], into net yield gains based on formula 4.4 in Chapter 4. Note that unlike expected yield gains, the additional input costs associated with each experiment were not expressed as minimum, most likely, and maximum possible values. This deterministic approach was followed because the estimates of changes in input requirements and input costs were obtained from a variety of sources that are more reliable than using subjective estimates from expert survey only. As explained in Chapter 4, the additional

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[70] The simulations for the current study included over a hundred spreadsheet templates and tables for six experiments across zones and under various scenarios. Not all of these tables are reported here but are available from the author.

[71] No additional input costs were predicted for the pruning experiment (see partial budget analysis in section 3 of this chapter)

Table 5.52 Adjusting Gross Yield Gains (Experiment 1) - Baseline: pesticide-based scenario

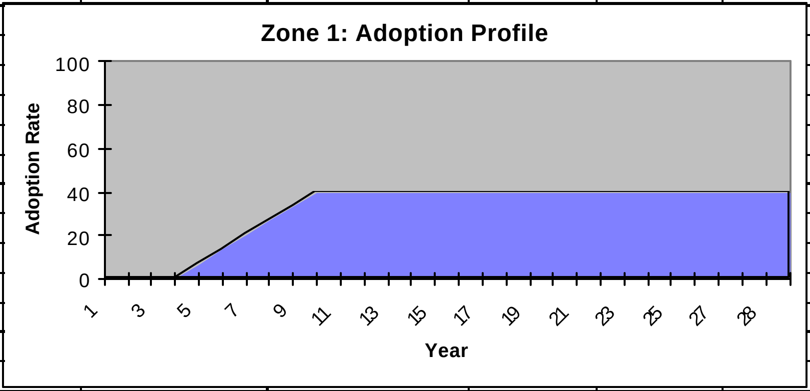
	Estimated Net Yield Gain % Minimum K_l	% Likely K_m	% Maximum K_h	Estimated Dissemination Threshold K_a	Probability of Exceeding Threshold (%) (Calculated)[1]	Conditional Gross Yield Gain (%) (Calculated)[1]	Adjusted Gross Yield Gain (%) (Calculated)	
Zone 1	11.00	17.00	28.00	17.00	64.7	20.2	13.1	
Zone 2	8.00	13.00	22.00	12.00	77.1	15.4	11.9	
Zone 3	7.00	14.00	18.00	12.00	67.5	19.3	13.0	
	[1]Calculated using formulas 4.6-4.9 in Chapter 4							
Am	Bm1	Ba	A*Bm-A*Ba		Ah	Bh	Bm2	A*Bh-A*Bm
0.019607843	48.16667	48.16667	0.00		0.010695187	3658.666667	2408.333333	13.372549
0.028571429	56.33333	0	1.6095238		0.015873016	1774.666667	1126.666667	10.285714
0.025974026	228.6667	-57.16667	7.4242424		0.045454545	972	849.3333333	5.5757576

Table 5.53 Partial commodity budgets and expected net yield gains (Experiment 1) - Baseline: pesticide-based scenario

Zone 1		Minimum	Most Likely	Maximum						
a)	Elicited expected gross yield gains (Kg)	61	72	155		$_{\Lambda}q$				
b)	Current average farm yield (Kg/Ha)	552	552	552		q				
c)	Commodity price per Kg (LEK)	300	300	300		P				
d)	Elicited additional input costs per Kg (LEK)	0	0	0		$_{\Lambda}C$		0		
e)	Input costs in equivalent commodity weight (Kg) [d/c*b]	0	0	0		$c={}_{\Lambda}C/(P*q)$				
f)	Net yield gain (Kg) [a-e]	61	72.312	155		$_{\Lambda}qn={}_{\Lambda}q-c$				
g)	Expected net yield gains (%) [(f/b)*100]	11	13	28		$E({}_{\Lambda}qn)={}_{\Lambda}qn/q$				
Zone 2		Minimum	Most Likely	Maximum	Price = 300 Lek/kg oil					
					Current Yield = (20 kg/tree)*(120 tree/ha)*(23%)					
a)	Elicited expected gross yield gains (Kg)	44	66	121			= 552 kg oil/ha			
b)	Current average farm yield (Kg/Ha)	552	552	552						
c)	Commodity price per Kg (LEK)	300	300	300						
d)	Elicited additional input costs per Kg (LEK)	0	0	0						
e)	Input costs in equivalent commodity weight (Kg) [d/c*b]	0	0	0						
f)	Net yield gain (Kg) [a-e]	44	66	121	Current Yield (kg/ha)			552	Adjusted Gross Yield Gain (%)	
g)	Expected net yield gains (%) [(f/b)*100]	8	12	22						
						exp. Gross yield gain (%)				
						11	17	28	13.1	
Zone 3		Minimum	Most Likely	Maximum		8	13	22	11.9	
						7	14	18	13	
a)	Elicited expected gross yield gains (Kg)	39	72	99		exp. Gross yield gain (kg of oil)			(Kg)	
b)	Current average farm yield (Kg/Ha)	552	552	552		61	94	155	72	
c)	Commodity price per Kg (LEK)	300	300	300		44	72	121	66	
d)	Elicited additional input costs per Kg (LEK)	0	0	0		39	77	99	72	
e)	Input costs in equivalent commodity weight (Kg) [d/c*b]	0	0	0						
f)	Net yield gain (Kg) [a-e]	39	71.76	99						
g)	Expected net yield gains (%) [(f/b)*100]	7	13	18						

Table 5.54 Estimating the technology adoption profile (Experiment 1) - Baseline: pesticide-based scenario

Zone 1	Research & Development Lag (Years)	Maximum Adoption (Years - Cummulative)	Start of Dis-adoption (Years - Cummulative)	Complete Dis-adoption (Years - Cummulative)	Maximum Adoption Rate (%)
	4	10	na	na	40
Calculated Profile					
Year	**Phase**	**Rate**			
1	RESEARCH LAG	0			
2	RESEARCH LAG	0			
3	RESEARCH LAG	0			
4	RESEARCH LAG	0			
5	INITIAL ADOPTION	7			
6	INITIAL ADOPTION	13			
7	INITIAL ADOPTION	20			
8	INITIAL ADOPTION	27			
9	INITIAL ADOPTION	33			
10	INITIAL ADOPTION	40			
11	MAX. ADOPTION	40			
12	MAX. ADOPTION	40			
13	MAX. ADOPTION	40			
14	MAX. ADOPTION	40			
15	MAX. ADOPTION	40			
16	MAX. ADOPTION	40			
17	MAX. ADOPTION	40			
18	MAX. ADOPTION	40			
19	MAX. ADOPTION	40			
20	MAX. ADOPTION	40			
21	MAX. ADOPTION	40			
22	MAX. ADOPTION	40			
23	MAX. ADOPTION	40			
24	MAX. ADOPTION	40			
25	MAX. ADOPTION	40			
26	MAX. ADOPTION	40			
27	MAX. ADOPTION	40			
28	MAX. ADOPTION	40			
28	MAX. ADOPTION	40			
30	MAX. ADOPTION	40			



input costs derived from a combination of data obtained through partial budget analysis, farmer interviews, field records, and expert survey provide more consistency in evaluation results that what would have been otherwise.

Step 3: Estimating the technology adoption profile. Table 5.54 (above) reports the predicted adoption profile based on estimated research and adoption lags for zone 1. For example, as shown in table 5.54, no adoption occurs during the four-year research lag, during which time the IPM package related to experiment 1 is under development. During the phase of increasing adoption, the rate of adoption is predicted to increase nearly 7% per year between year four and year 10. The rate of adoption reaches 40% after year 10 and remains the same from that year on. No disadoption stage was foreseen assuming that this IPM package will not become obsolete over a 30 year period.

Step 4: Estimating NPV of total benefits. The net present value (NPV) of total benefits from olive IPM CRSP research was computed based on the economic surplus equilibrium displacement model of the Albanian olive market developed in Chapter 3. In order to simulate changes in economic surpluses due to yield gains, first the "after demand shift" equilibrium prices and quantities for each experiment and across zones (referring to equilibrium at point A' in Figure 3.6) were computed using formulas 3.54-3.55 in Chapter 3. These "after demand shift" equilibrium prices and quantities for the two baseline scenarios are reported in table 5.55 and 5.56, respectively. Table 5.57 shows NPV of total benefits for zone 1. It includes initial "after demand shift" olive oil price ($2,185.48 per ton) and quantity (4,884.2 ton) as derived from table 5.55, price elasticity of demand and supply, net yield gain (%), and net price gain ($/ton). It also includes research lags and adoption profile. Net K-shift, the proportional downward shift in the supply curve for each year, is calculated as a product of net yield gain (column 3) and adoption rate (column 6). NPV of total benefits (column 10) is computed as a product of base price, quantities, and net shift in supply (column 7). The NPV of total benefits with a 6% real discount rate is given in the shaded area on the top of the table.

Step 5: Estimating the NPV of total economic surplus and its distribution to producers and consumers. Table 5.58 shows the computational procedures for estimating changes in total, producer and consumer economic surpluses using formulas 3.51-3.53 given in Chapter 3.

The net k-shift is calculated as (Column 7) = ((Column 3)*(Column6))/100/supply elasticity). Recall that the supply elasticity is set to one in this study. Net proportionate price decrease is calculated as (Column 9) = (Column 7)*(Column 2)/((Column 2)+(Column 1)). The change in total economic surplus (in Albanian Lek) is calculated for each year as (Column 11) = (Column 7)*(Column 8)*(Column 10)*(1+0.5*(Column 9)*(Column 1))). The change in consumer surplus is calculated as (Column 12) = (Column 8)*(Column 9)*(Column 10)*[1+(0.5*(Column 9)*(Column 1))].

Table 5.55 The values of "after demand shift" equilibrium olive quantities and prices

(Baseline: pesticide-based scenario)

Demand elasticity	Supply elasticity	Adjusted price gain (Lek/Ton)	Adjusted price gain ($/Ton)	Initial production (Ton)	Initial price ($/Ton)	Adjusted initial production	Adjusted initial price ($/Ton)
0.8	1.0	(c)	(d)	(e)	(f)	(Q'_0)	(P'_0)
Experiment 1							
Zone 1		24,000	171.43	4,789	2,143	4,884.2	2,185.48
Zone 2		19,250	137.50	7,986	2,143	8,062.4	2,163.36
Zone 3		15,640	111.71	2,429	2,143	2,491.1	2,197.61
Experiment 2							
Zone 1		22,320	159.43	4,789	2,143	4,877.6	2,182.49
Zone 2		13,940	99.57	7,986	2,143	8,041.3	2,157.70
Zone 3		13,500	96.43	2,429	2,143	2,482.6	2,190.12
Experiment 3							
Zone 1		12,870	91.93	4,789	2,143	4,840.1	2,165.71
Zone 2		11,136	79.54	7,986	2,143	8,030.2	2,154.72
Zone 3		9,828	70.20	2,429	2,143	2,468.0	2,177.27
Experiment 4							
Zone 1		31,080	222.00	4,789	2,143	4,912.3	2,198.05
Zone 2		20,400	145.71	7,986	2,143	8,067.0	2,164.58
Zone 3		16,740	119.57	2,429	2,143	2,495.4	2,201.46
Experiment 5							
Zone 1		19,200	137.14	4,789	2,143	4,865.2	2,176.95
Zone 2		16,500	117.86	7,986	2,143	8,051.5	2,160.43
Zone 3		13,870	99.07	2,429	2,143	2,484.0	2,191.42
Experiment 6							
Zone 1		22,100	157.86	4,789	2,143	4,876.7	2,182.10
Zone 2		20,010	142.93	7,986	2,143	8,065.4	2,164.17
Zone 3		15,840	113.14	2,429	2,143	2,491.9	2,198.31

Table 5.56 The values of "after demand shift" equilibrium olive quantities and prices

(Baseline: minimum practice scenario)

Demand elasticity	Supply elasticity	Adjusted price gain (Lek/Ton)	Adjusted price gain ($/Ton)	Initial production (Ton)	Initial price ($/Ton)	Adjusted initial production (Q'_0)	Adjusted initial price ($/Ton) (P'_0)
0.8	1.0						
Experiment 1							
Zone 1		24,000	171.43	3,591	2,143	3,686	2,200
Zone 2		19,250	137.50	5,989	2,143	6,065	2,170
Zone 3		15,640	111.71	1,822	2,143	1,884	2,216
Experiment 2							
Zone 1		22,320	159.43	3,591	2,143	3,680	2,196
Zone 2		13,940	99.57	5,989	2,143	6,044	2,163
Zone 3		13,500	96.43	1,822	2,143	1,876	2,206
Experiment 3							
Zone 1		12,870	91.93	3,591	2,143	3,642	2,173
Zone 2		11,136	79.54	5,989	2,143	6,033	2,159
Zone 3		9,828	70.20	1,822	2,143	1,861	2,189
Experiment 4							
Zone 1		31,080	222.00	3,591	2,143	3,714	2,216
Zone 2		20,400	145.71	5,989	2,143	6,070	2,172
Zone 3		16,740	119.57	1,822	2,143	1,888	2,221
Experiment 5							
Zone 1		19,200	137.14	3,591	2,143	3,667	2,188
Zone 2		16,500	117.86	5,989	2,143	6,054	2,166
Zone 3		13,870	99.07	1,822	2,143	1,877	2,208
Experiment 6							
Zone 1		22,100	157.86	3,591	2,143	3,679	2,195
Zone 2		20,010	142.93	5,989	2,143	6,068	2,171
Zone 3		15,840	113.14	1,822	2,143	1,885	2,217

The change in producer surplus is calculated as (Column 13) = (Column 11) - (Column 12). The NPV of economic surpluses with a 6% real discount rate is given in the shaded area in both U.S. dollars and Albanian lek on the top of the table 5.59 (Table 5.58).

Table 5.57 Estimating total benefit (Experiment 1) - Baseline: pesticide-based scenario

Total Benefits from zone 1								
with a 6% Real Discount Rate.			USD	$7,525,177				
Absolute			LEK	1,053,524,795				
Demand	Supply							
Elasicity	Elasicity	Adjusted						
0.8	1	Net Yield	Adjusted	Adoption Profile (in cummulative years)				Maximum
Initial	Initial	Gain	net price gain	Research	Maximum	Start of Dis-	Complete	Adoption
Price	Quantity	(%)	($/Ton)	Lag	Adoption	Adoption	Dis-adoption	Rate (%)
2,142.86	4,789	12.2	171	4	10	na	na	40

Year	Price	Quantity	Net Yield Gain (%)	Adoption Phase	Adoption Rate (%)	Net K Shift[a]	Total Benefits (USD)
1	2,185	4,884	12.2	RESEARCH LAG	0	0.000	0
2	2,228	4,979	12.2	RESEARCH LAG	0	0.000	0
3	2,271	5,075	12.2	RESEARCH LAG	0	0.000	0
4	2,313	5,170	12.2	RESEARCH LAG	0	0.000	0
5	2,356	5,265	12.2	INITIAL ADOPTION	7	0.008	100,890
6	2,399	5,360	12.2	INITIAL ADOPTION	13	0.016	209,145
7	2,441	5,456	12.2	INITIAL ADOPTION	20	0.024	324,964
8	2,484	5,551	12.2	INITIAL ADOPTION	27	0.033	448,545
9	2,526	5,646	12.2	INITIAL ADOPTION	33	0.041	580,086
10	2,569	5,741	12.2	INITIAL ADOPTION	40	0.049	719,785
11	2,612	5,837	12.2	MAX. ADOPTION	40	0.049	743,863
12	2,654	5,932	12.2	MAX. ADOPTION	40	0.049	768,337
13	2,697	6,027	12.2	MAX. ADOPTION	40	0.049	793,207
14	2,739	6,122	12.2	MAX. ADOPTION	40	0.049	818,473
15	2,782	6,218	12.2	MAX. ADOPTION	40	0.049	844,135
16	2,825	6,313	12.2	MAX. ADOPTION	40	0.049	870,194
17	2,867	6,408	12.2	MAX. ADOPTION	40	0.049	896,648
18	2,910	6,503	12.2	MAX. ADOPTION	40	0.049	923,499
19	2,953	6,599	12.2	MAX. ADOPTION	40	0.049	950,746
20	2,995	6,694	12.2	MAX. ADOPTION	40	0.049	978,389
21	3,038	6,789	12.2	MAX. ADOPTION	40	0.049	1,006,428
22	3,080	6,884	12.2	MAX. ADOPTION	40	0.049	1,034,863
23	3,123	6,979	12.2	MAX. ADOPTION	40	0.049	1,063,694
24	3,166	7,075	12.2	MAX. ADOPTION	40	0.049	1,092,921
25	3,208	7,170	12.2	MAX. ADOPTION	40	0.049	1,122,545
26	3,251	7,265	12.2	MAX. ADOPTION	40	0.049	1,152,565
27	3,293	7,360	12.2	MAX. ADOPTION	40	0.049	1,182,980
28	3,336	7,456	12.2	MAX. ADOPTION	40	0.049	1,213,792
29	3,379	7,551	12.2	MAX. ADOPTION	40	0.049	1,245,000
30	3,421	7,646	12.2	MAX. ADOPTION	40	0.049	1,276,604

Table 5.58 Estimating changes in economic surpluses (Experiment 1) - Baseline: pesticide-based scenario

Zone:	1				Net Present Value of Economic Surplus with a 6% discount rate			
					Total	Consumer	Producer	
				USD	$7,602,227	$4,223,459	$3,378,767	
				LEK	1,064,311,713	591,284,285	473,027,428	
Absolute Demand Elasicity	Supply Elasicity							
0.8	1	Adjusted net price gain ($/Ton)	Adjusted Net Yield Gain (%)	Adoption Profile (in cummulative years)				Maximum Adoption Rate (%)
Initial Price	Initial Quantity			Research Lag	Maximum Adoption	Start of Dis-Adoption	Complete Dis-adoption	
2,142.86	4,789	171.43	12.2	4	10	na	na	40

Year	(1) Demand Elasicity	(2) Supply Elasicity	(3) Net Yield Gain (%)	(5) Adoption Phase	(6) Adoption Rate (%)	(7) Net K Shift[a]	(8) Olive oil Price	(9) Net Price Decrease (Z)[b]	(10) Quantity Metric Tonnes	(11) Change in Total Surplus[c] (USD)	(12) Change in Consumer Surplus[d] (US
1	0.8	1	12.2	RESEARCH LAG	0	0.000	2,185	0.000	4,884	0	0
2	0.8	1	12.2	RESEARCH LAG	0	0.000	2,228	0.000	4,979	0	0
3	0.8	1	12.2	RESEARCH LAG	0	0.000	2,271	0.000	5,075	0	0
4	0.8	1	12.2	RESEARCH LAG	0	0.000	2,313	0.000	5,170	0	0
5	0.8	1	12.2	INITIAL ADOPTION	7	0.008	2,356	0.005	5,265	101,072	56,151
6	0.8	1	12.2	INITIAL ADOPTION	13	0.016	2,399	0.009	5,360	209,901	116,612
7	0.8	1	12.2	INITIAL ADOPTION	20	0.024	2,441	0.014	5,456	326,726	181,514
8	0.8	1	12.2	INITIAL ADOPTION	27	0.033	2,484	0.018	5,551	451,788	250,993
9	0.8	1	12.2	INITIAL ADOPTION	33	0.041	2,526	0.023	5,646	585,328	325,182
10	0.8	1	12.2	INITIAL ADOPTION	40	0.049	2,569	0.027	5,741	727,591	404,217
11	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,612	0.027	5,837	751,929	417,739
12	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,654	0.027	5,932	776,669	431,483
13	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,697	0.027	6,027	801,809	445,449
14	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,739	0.027	6,122	827,349	459,638
15	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,782	0.027	6,218	853,289	474,050
16	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,825	0.027	6,313	879,630	488,684
17	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,867	0.027	6,408	906,372	503,540
18	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,910	0.027	6,503	933,514	518,619
19	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,953	0.027	6,599	961,056	533,920
20	0.8	1	12.2	MAX. ADOPTION	40	0.049	2,995	0.027	6,694	988,999	549,444
21	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,038	0.027	6,789	1,017,342	565,190
22	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,080	0.027	6,884	1,046,085	581,158
23	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,123	0.027	6,979	1,075,229	597,350
24	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,166	0.027	7,075	1,104,774	613,763
25	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,208	0.027	7,170	1,134,718	630,399
26	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,251	0.027	7,265	1,165,063	647,257
27	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,293	0.027	7,360	1,195,809	664,338
28	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,336	0.027	7,456	1,226,955	681,642
29	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,379	0.027	7,551	1,258,502	699,168
30	0.8	1	12.2	MAX. ADOPTION	40	0.049	3,421	0.027	7,646	1,290,448	716,916

Procedures followed for simulating quality-improving effects are similar to the ones described above for all experiments. However, as shown in table 5.59, to insure the consistency of the results the probabilities of research success derived from the probability distribution of yield gains for each experiment and zone are used here as well. Average price gains are computed based on the minimum, most likely, and maximum possible values of elicited price gains due to quality improvement. Then, these simple average price gains are multiplied by the probability of research success to come up with the net price gains.

Table 5.59 Estimating net price gains (Experiment 1)

Zones	Estimated Price Gain %			Average Price Gain (%)	Probability of Research Success (%)	Adjusted Net Price Gain (%)
	Minimum K_l	Most Likely K_m	Maximum K_h	K_a	(Calculated)	(Calculated)
Zone 1	8	12	15	12	65	8
Zone 2	5	8	12	8	77	6
Zone 3	5	7	11	8	68	5

5.4.3 Evaluation results

Table 5.60 shows the results of economic surplus analysis for the four olive IPM strategies as well as the two potential research themes conducted relative to the pesticide-based scenario. The simulation results represent the aggregates of the potential economic impacts due to IPM CRSP research-induced gains in olive yields and product quality across major olive-growing zones. For instance, the first row for the harvest timing and olive fly control strategy (Experiment 1) shows that a 12% supply shift for olive oil and a 8% demand shift due to quality improvement would generate a total of $12.4 million in benefits to zone 1 (the research target zone). Of this total, $7.6 million (61%) is due to yield gains and $4.8 million (39%) is due to quality improvement. The estimated changes in total economic surplus and its distribution to producers

Table 5.60 Potential economic surplus benefits generated by olive IPM CRSP reseach in Albania - Baseline: pesticide-based scenario

Experiments and Zones	Change in Consumer Surplus (USD) quality (a)	Change in Producer Surplus (USD) quality (b)	Change in Total Surplus (USD) quality (a+b)	Change in Consumer Surplus (USD) yield (c)	Change in Producer Surplus (USD) yield (d)	Change in Total Surplus (USD) yield (c+d)	Change in Total Consumer Surplus (USD) (e)	Change in Total Producer Surplus (USD) (f)	Change in Total Economic Surplus (USD) (e+f)
Experiment 1									
Zone 1	2,677,979	2,142,383	4,820,362	4,223,459	3,378,767	7,602,227	6,901,438	5,521,151	12,422,589
Zone 2	1,695,815	1,356,652	3,052,467	3,431,065	2,744,852	6,175,916	5,126,880	4,101,504	9,228,383
Zone 3	432,324	345,859	778,183	1,168,311	934,649	2,102,960	1,600,635	1,280,508	2,881,143
Total Exp 1	4,806,118	3,844,894	8,651,012	8,822,835	7,058,268	15,881,103	13,628,953	10,903,162	24,532,115
Experiment 2									
Zone 1	937,713	750,170	1,687,884	1,206,572	965,258	2,171,830	2,144,285	1,715,428	3,859,714
Zone 2	723,141	578,513	1,301,654	487,856	390,285	878,141	1,210,997	968,798	2,179,795
Zone 3	101,472	81,177	182,649	-104,663	-83,731	-188,394	-3,191	-2,554	-5,745
Total Exp 2	1,762,326	1,409,860	3,172,187	1,589,765	1,271,812	2,861,577	3,352,091	2,681,672	6,033,764
Experiment 3									
Zone 1	0	0	0	2,284,924	1,827,939	4,112,863	2,284,924	1,827,939	4,112,863
Zone 2	0	0	0	1,649,337	1,319,469	2,968,806	1,649,337	1,319,469	2,968,806
Zone 3	0	0	0	328,048	262,438	590,486	328,048	262,438	590,486
Total Exp 3	0	0	0	4,262,309	3,409,846	7,672,155	4,262,309	3,409,846	7,672,155
Experiment 4									
Zone 1	2,520,275	2,016,220	4,536,495	2,372,741	1,898,192	4,270,933	4,893,016	3,914,412	8,807,428
Zone 2	1,619,741	1,295,793	2,915,534	1,234,725	987,780	2,222,504	2,854,466	2,283,573	5,138,038
Zone 3	383,083	306,467	689,550	198,460	158,768	357,227	581,543	465,235	1,046,777
Total Exp 4	4,523,099	3,618,480	8,141,579	3,805,926	3,044,740	6,850,664	8,329,025	6,663,220	14,992,243
Experiment 5									
Zone 1	0	0	0	1,466,829	1,172,813	2,638,829	1,466,829	1,172,813	2,638,829
Zone 2	0	0	0	771,516	617,213	1,388,728	771,516	617,213	1,388,728
Zone 3	0	0	0	56,203	44,963	101,166	56,203	44,963	101,166
Total Exp 5	0	0	0	2,294,548	1,834,989	4,128,723	2,294,548	1,834,989	4,128,723
Experiment 6									
Zone 1	0	0	0	4,262,945	3,410,356	7,673,302	4,262,945	3,410,356	7,673,302
Zone 2	0	0	0	2,844,366	2,275,492	5,119,858	2,844,366	2,275,492	5,119,858
Zone 3	0	0	0	676,902	541,521	1,218,423	676,902	541,521	1,218,423
Total Exp 6	0	0	0	7,784,213	6,227,370	14,011,583	7,784,213	6,227,370	14,011,583
Total benefits	11,091,543	8,873,234	19,964,778	28,559,595	22,847,025	51,405,804	39,651,138	31,720,260	71,370,582
Total benefits (exp. 1-4)[1]	11,091,543	8,873,234	19,964,778	18,480,834	14,784,666	33,265,499	29,572,377	23,657,901	53,230,277

[1] Only experiments currently underway are considered in this total

and consumers vary widely across research themes and zones. Overall, the four olive IPM packages being developed through experiments 1-4 as well as the other two potential research themes promise positive net aggregate benefits for both producer and consumer groups (Figure 5.9).

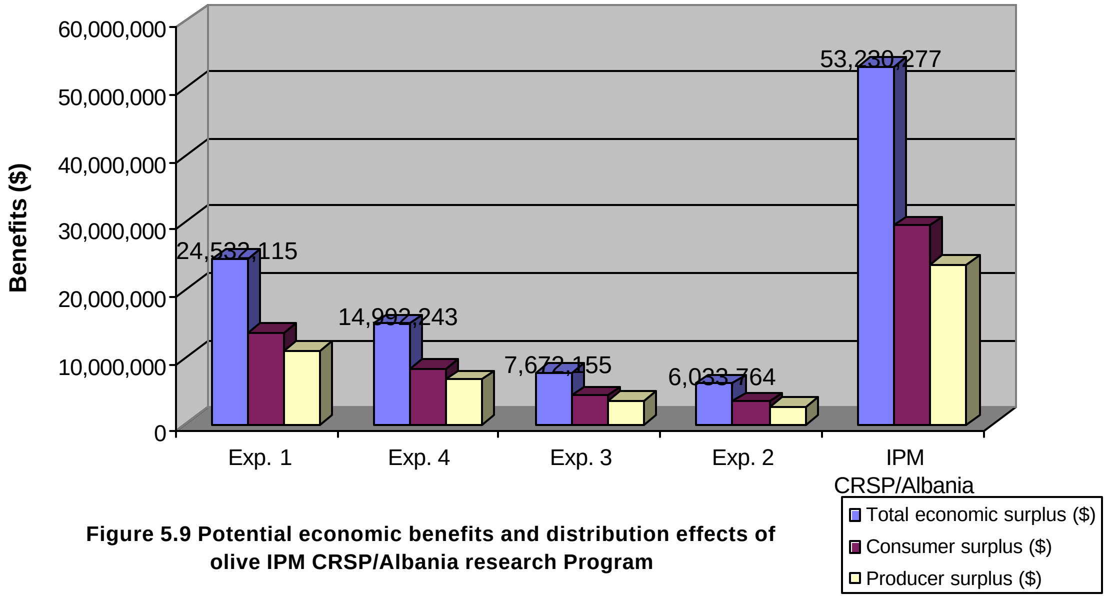


Figure 5.9 Potential economic benefits and distribution effects of olive IPM CRSP/Albania research Program

The harvest time and olive fly control strategy (experiment 1) has the highest present value of economic benefits ($24.5 million) followed by pheromone strategy (Exp. 4: $15 million) and pruning and copper treatment strategy (Exp. 3: $7.7 million). The vegetation management strategy (Exp. 2) has the lowest present value of economic benefits, which amounts to $6 million. The other two potential research themes, that is, harvest methods and irrigation, also are predicted to generate positive welfare effects of $4.1 million and $14 million, respectively. Nearly 63% of potential economic impacts attributed to olive IPM CRSP research comes from yield gains and the rest from quality gains. As expected from the elasticity assumption, consumer surplus changes comprise a slightly higher proportion (55%) of total economic surplus than changes in producer surplus (45%).

In table 5.61 the same information as in table 5.60 is presented in a different ordering so as to show the distribution of potential benefits in the research target zone as well as the research spillover effects in two other olive

Table 5.61 Potential economic surplus generated by olive IPM CRSP reseach across agro-ecological zones - Baseline: pesticide-based scenario

Zones and Experiments	Change in Consumer Surplus (USD) quality (a)	Change in Producer Surplus (USD) quality (b)	Change in Total Surplus (USD) quality (a+b)	Change in Consumer Surplus (USD) yield (c)	Change in Producer Surplus (USD) yield (d)	Change in Total Surplus (USD) yield (c+d)	Change in Total Consumer Surplus (USD) (e)	Change in Total Producer Surplus (USD) (f)	Change in Total Economic Surplus (USD) (e+f)
Zone 1									
Exp 1	2,677,979	2,142,383	4,820,362	4,223,459	3,378,767	7,602,227	6,901,438	5,521,151	12,422,589
Exp 2	937,713	750,170	1,687,884	1,206,572	965,258	2,171,830	2,144,285	1,715,428	3,859,714
Exp 3	0	0	0	2,284,924	1,827,939	4,112,863	2,284,924	1,827,939	4,112,863
Exp 4	2,520,275	2,016,220	4,536,495	2,372,741	1,898,192	4,270,933	4,893,016	3,914,412	8,807,428
Exp 5	0	0	0	1,466,829	1,172,813	2,638,829	1,466,829	1,172,813	2,638,829
Exp 6	0	0	0	4,262,945	3,410,356	7,673,302	4,262,945	3,410,356	7,673,302
Total Z1	6,135,967	4,908,773	11,044,741	15,817,470	12,653,326	28,469,983	21,953,437	17,562,099	39,514,724
Zone 2									
Exp 1	1,695,815	1,356,652	3,052,467	3,431,065	2,744,852	6,175,916	5,126,880	4,101,504	9,228,383
Exp 2	723,141	578,513	1,301,654	487,856	390,285	878,141	1,210,997	968,798	2,179,795
Exp 3	0	0	0	1,649,337	1,319,469	2,968,806	1,649,337	1,319,469	2,968,806
Exp 4	1,619,741	1,295,793	2,915,534	1,234,725	987,780	2,222,504	2,854,466	2,283,573	5,138,038
Exp 5	0	0	0	771,516	617,213	1,388,728	771,516	617,213	1,388,728
Exp 6	0	0	0	2,844,366	2,275,492	5,119,858	2,844,366	2,275,492	5,119,858
Total Z2	4,038,697	3,230,958	7,269,655	10,418,864	8,335,091	18,753,953	14,457,561	11,566,049	26,023,608
Zone 3									
Exp 1	432,324	345,859	778,183	1,168,311	934,649	2,102,960	1,600,635	1,280,508	2,881,143
Exp 2	101,472	81,177	182,649	-104,663	-83,731	-188,394	-3,191	-2,554	-5,745
Exp 3	0	0	0	328,048	262,438	590,486	328,048	262,438	590,486
Exp 4	383,083	306,467	689,550	198,460	158,768	357,227	581,543	465,235	1,046,777
Exp 5	0	0	0	56,203	44,963	101,166	56,203	44,963	101,166
Exp 6	0	0	0	676,902	541,521	1,218,423	676,902	541,521	1,218,423
Total Z3	916,879	733,503	1,650,382	2,323,261	1,858,608	4,181,868	3,240,140	2,592,111	5,832,250
Total benefits	11,091,543	8,873,234	19,964,778	28,559,595	22,847,025	51,405,804	39,651,138	31,720,260	71,370,582
Total benefits (exp. 1-4)	11,091,543	8,873,234	19,964,778	18,480,834	14,784,666	33,265,499	29,572,377	23,657,901	53,230,277

growing zones. In general, the olive IPM strategies considered in this study are predicted to generate positive economic surplus benefits in all zones except for the vegetation management strategy (exp. 2), which is expected to yield negative welfare effects in the Adriatic zone (zone 2). Changes in economic surplus vary markedly across zones according to their different potential for technology generation and production base. Fifty-six percent of producer surplus benefits are concentrated in the research target zone (Ionic zone). However, the Adriatic zone also shows substantial producer benefits (36%) followed by the Near-Adriatic zone (8%). Distribution of consumer surplus benefits also reflects the size of production base for each zone to which the supply and demand shifts were applied.

Table 5.62 shows the results of economic surplus analysis for the four olive IPM strategies as well as the two potential research themes conducted relative to the minimum practice scenario. The results indicate that under this scenario, the IPM CRSP/Albania program would generate nearly $39 million in benefits to the country as a whole. Of this total, $21.6 million (55%) is accrued by consumers and $17.3 million (45%) goes to olive producers. The spatial distribution of research benefits is as follows: $22.6 million (58%) is expected to be generated in the research target zone and the rest ($16.3 million, 42%) constitutes research spillover effects in the adjacent olive growing zones. As with the previous scenario, the harvest time and olive control strategy (exp. 1) is expected to yield the highest present value of economic surplus benefits ($21.1 million) followed by pheromone strategy (exp. 4), ($11 million), vegetation management strategy (exp.2), ($4.3 million), and pruning and copper treatment strategy (exp. 3), ($2.5 million). However, note that several olive IPM practices including vegetation management strategy (exp. 2) and harvest method practice (exp. 5) are expected to yield negative welfare effects in the Near-Adriatic zone (Zone 3). Also, pruning and copper treatment strategy (exp. 3) is not expected to generate any welfare effect in the zone 3.

Table 5.62 Potential economic surplus benefits generated by olive IPM CRSP reseach in Albania - Baseline: minimum practice scenario

Experiments and Zones	**Change in Consumer Surplus (USD) quality** (a)	**Change in Producer Surplus (USD) quality** (b)	**Change in Total Surplus (USD) quality** (a+b)	**Change in Consumer Surplus (USD) yield** (c)	**Change in Producer Surplus (USD) yield** (d)	**Change in Total Surplus (USD) yield** (c+d)	**Change in Total Consumer Surplus (USD)** (e)	**Change in Total Producer Surplus (USD)** (f)	**Change in Total Economic Surplus (USD)** (e+f)
Experiment 1									
Zone 1	2,340,228	1,872,182	4,212,410	3,716,481	2,973,185	6,689,666	6,056,709	4,845,367	10,902,076
Zone 2	1,389,787	1,111,830	2,501,617	2,824,613	2,259,691	5,084,304	4,214,401	3,371,521	7,585,921
Zone 3	392,756	314,205	706,960	1,069,160	855,328	1,924,489	1,461,916	1,169,533	2,631,449
Total Exp 1	4,122,771	3,298,217	7,420,987	7,610,255	6,088,204	13,698,459	11,733,026	9,386,421	21,119,446
Experiment 2									
Zone 1	815,649	652,519	1,468,167	844,605	675,684	1,520,288	1,660,253	1,328,203	2,988,456
Zone 2	578,379	462,703	1,041,082	195,689	156,551	352,240	774,068	619,254	1,393,322
Zone 3	90,271	72,217	162,488	-140,613	-112,490	-253,103	-50,341	-40,273	-90,614
Total Exp 2	1,484,299	1,187,439	2,671,737	899,681	719,745	1,619,426	2,383,979	1,907,184	4,291,163
Experiment 3									
Zone 1	0	0	0	1,032,333	825,866	1,858,199	1,032,333	825,866	1,858,199
Zone 2	0	0	0	373,960	299,168	673,128	373,960	299,168	673,128
Zone 3	0	0	0	0	0	0	0	0	0
Total Exp 3	0	0	0	1,406,293	1,125,034	2,531,327	1,406,293	1,125,034	2,531,327
Experiment 4									
Zone 1	2,293,213	1,834,570	4,127,783	1,519,742	1,215,794	2,735,536	3,812,955	3,050,364	6,863,318
Zone 2	1,338,518	1,070,814	2,409,332	511,814	409,451	921,265	1,850,332	1,480,265	3,330,597
Zone 3	353,841	283,073	636,914	92,267	73,814	166,081	446,108	356,887	802,995
Total Exp 4	3,985,572	3,188,457	7,174,029	2,123,823	1,699,059	3,822,882	6,109,395	4,887,516	10,996,911
Experiment 5									
Zone 1	0	0	0	800,496	640,397	1,440,893	800,496	640,397	1,440,893
Zone 2	0	0	0	317,785	254,228	572,013	317,785	254,228	572,013
Zone 3	0	0	0	-51,693	-41,354	-93,048	-51,693	-41,354	-93,048
Total Exp 5	0	0	0	1,066,588	853,270	1,919,858	1,066,588	853,270	1,919,858
Experiment 6									
Zone 1	0	0	0	3,826,006	3,060,805	6,886,811	3,826,006	3,060,805	6,886,811
Zone 2	0	0	0	2,392,768	1,914,214	4,306,982	2,392,768	1,914,214	4,306,982
Zone 3	0	0	0	610,778	488,622	1,099,401	610,778	488,622	1,099,401
Total Exp 6	0	0	0	6,829,552	5,463,642	12,293,194	6,829,552	5,463,642	12,293,194
Total benefits	9,592,641	7,674,113	17,266,754	19,936,191	15,948,953	35,885,145	29,528,832	23,623,066	53,151,898
Total benefits (exp. 1-4)[1]	9,592,641	7,674,113	17,266,754	12,040,052	9,632,041	21,672,093	21,632,693	17,306,154	38,938,847

[1] Only experiments currently underway are considered in this total.

The potential welfare effects and their distribution among groups of consumers and producers for the “with” research scenario were compared with those of the without research scenarios (Table 5.63). As noted earlier, the experts interviewed predicted that some yield gains could be expected from the widespread application of pesticide-based pest control practices and other management practices in the next thirty years. As table 5.63 shows, the with research scenario would generate $39 million and $53.2 million in benefits to producers and consumers having as baseline scenario 1 and 2, respectively, which are four to five times higher than the potential benefits that would be generated from without research/with pesticides scenario and much higher than those predicted for without research/without pesticides scenario. Note that the spatial distribution of welfare gains reveals similar patterns for all three scenarios with over 90% of benefits generated in the Ionic and Adriatic zones (zones 1 and 2) and the rest in the Near-Adriatic zone (zone 3).

Table 5.63 Potential economic benefits and distribution effects for different scenarios

	Economic Surplus Benefits (USD)		
Scenarios	Change in consumer surplus	Change in producer surplus	Change in total surplus
Scenario 1 Without research without pesticides	1,266,434	1,013,147	2,279,581
Zone 1	610,606	488,485	1,099,091
Zone 2	586,646	469,316	1,055,962
Zone 3	69,183	55,346	124,529
Scenario 2 Without research with pesticides	5,844,309	4,675,448	10,519,757
Zone 1	2,582,973	2,066,379	4,649,352
Zone 2	2,991,874	2,393,499	5,385,373
Zone 3	269,462	215,570	485,032
With research Scenario (Baseline: Scenario 1)	21,632,693	17,306,154	38,938,847
Zone 1	12,562,250	10,049,800	22,612,049
Zone 2	7,212,760	5,770,208	12,982,968
Zone 3	1,857,683	1,486,146	3,343,830
With research Scenario (Baseline: Scenario 2)	29,572,377	23,657,901	53,230,277
Zone 1	16,223,663	12,978,930	29,202,594
Zone 2	10,841,680	8,673,344	19,515,022
Zone 3	2,507,035	2,005,627	4,512,661

5.4.4 Program-level aggregation

In order to assess the overall economic efficiency of the IPM CRSP/Albania program, first the potential benefits generated from each IPM strategy and for the whole program were weighed against the research program costs. Next, the changes in economic surplus benefits were aggregated into summary measures of research benefits such as the net present value (NPV) and internal rate of return (IRR) as discussed in chapter 3. A detailed explanation of the calculations and assumptions made with respect to the cost structures of the IPM CRSP/Albania program appears in appendix E. The total costs considered in the with research scenario amount to $975,440.

The NPVs and IRRs for each IPM strategy and for the whole program with reference to the two baseline scenarios considered are presented in table 5.64. The internal rate of return for individual IPM strategies are 81% for harvest timing and olive fly control strategy (exp.1), 57% for pheromone-based olive fly control strategy (exp. 4), 53% for pruning and copper treatment strategy (exp. 3), and 49% for vegetation management strategy (exp.2). Referring to full pesticide baseline, the net present value for the whole program is $52.5 million and the internal rate of return is 64%, whereas under the minimum practice baseline, these figures are $39 million and 56%, respectively. Although, the with research scenario involves the joint adoption of technologies from the four research themes, this study was based on the partial adoption rates for each research theme. Therefore, in the absence of joint adoption estimates, the NPV for the whole program was computed by adding up the separate welfare effects of each research theme, presuming the errors from ignoring interaction effects might be small. This aggregation issue is further discussed in the next chapter.

Table 5.64 NPV and IRR of economic surplus benefits of IPM CRSP/Albania research program

	Baseline: pesticide-based scenario				Baseline: minimum practice scenario			
Experiments and Zones	Total Economic Surplus (USD)	Research cost (USD)	Net Present Value (NPV) (USD)	Internal Rate of Return (IRR) (%)	Total Economic Surplus (USD)	Research cost (USD)	Net Present Value (NPV) (USD)	Internal Rate of Return (IRR) (%)
Experiment 1	24,532,115	282,878	24,249,237	81	21,119,446	282,878	20,836,569	74
Zone 1	12,422,589		12,328,296		10,902,076		10,807,784	
Zone 2	9,228,383		9,134,091		7,585,921		7,491,629	
Zone 3	2,881,143		2,786,850		2,631,449		2,537,156	
Experiment 2	6,033,764	214,597	5,819,167	49	4,291,163	214,597	4,076,566	42
Zone 1	3,859,714		3,788,182		2,988,456		2,916,923	
Zone 2	2,179,795		2,108,263		1,393,322		1,321,789	
Zone 3	-5,745		-77,277		-90,614		-162,147	
Experiment 3	7,672,155	204,842	7,467,313	53	2,531,327	204,842	2,326,484	33
Zone 1	4,112,863		4,044,582		1,858,199		1,789,918	
Zone 2	2,968,806		2,900,525		673,128		604,847	
Zone 3	590,486		522,205		0		-68,281	
Experiment 4	14,992,243	273,123	14,719,120	57	10,996,911	273,123	10,723,788	49
Zone 1	8,807,428		8,716,387		6,863,318		6,772,277	
Zone 2	5,138,038		5,046,997		3,330,597		3,239,556	
Zone 3	1,046,777		955,736		802,995		711,954	
IPM CRSP/Albania	53,230,277	975,440	52,254,837	64	38,938,847	975,440	37,963,407	56
Zone 1	29,202,594		28,877,447		22,612,049		22,286,903	
Zone 2	19,515,022		19,189,876		12,982,968		12,657,821	
Zone 3	4,512,661		4,187,514		3,343,830		3,018,683	

5.4.5 Sensitivity analysis

The ex ante evaluation results presented above comprise future benefits from IPM research projects that are at present underway. The parameters that are uncertain are the research outcomes and the rates of adoption of the resulting technologies. Hence, the research scenario is defined as a "best-bet" scenario in terms of these uncertain aspects. A sensitivity analysis was conducted to explore the implications of alternative scenarios given uncertainty about the key technology and adoption elements compared to the results of the model that uses pesticide-based scenario as a baseline. The results of sensitivity analysis for different values of technology and adoption variables are presented in table 5.65.

Elasticity assumptions affect the distribution of benefits between producers and consumers much more than the size of total benefits. Doubling the absolute value of demand elasticity from –0.8 to 1.6 reduces the size of economic surplus benefits from $53.2 million to $45.8 million. Additionally, under this scenario, the more elastic demand relative to olive oil supply implies a greater producer share of total research benefits as compared to the consumer share. A fifty percent reduction in the elasticity of supply, on the other hand, has only a slight impact on total estimated benefits but markedly affects the distribution effects. This reduction in supply elasticity leads to an increase in the absolute unit cost reduction. That is, it further increases producer share of benefits (from $28.1 million to $33.4 million) as well as the consumer share of benefits (from $17.6 million to $20.9 million) as compared to the doubling demand elasticity scenario. As explained in figure 3.6 (chapter 3), this is attributed to the fact that when a technology innovation involves simultaneous shifts in supply and demand, the net effect is for quantity to increase more and price to fall less than the case when research induces a shift in supply only.

The simulation for the scenario involving a 10 percent increase in expected net yield and price gains revealed a 12 percent increase in total benefits compared to the base scenario. However, this change only slightly affected the distribution of benefits between producers and consumers. The 10 percent increase in maximum adoption rate yielded changes in total benefits of

Table 5.65 Sensitivity analysis on demand elasticity, supply elasticity, potential technology generation, and adoption.

Experiments	PV of economic surplus benefits ($)	Base Model (baseline: pesticide-based scenario)	Double demand elasticity η=1.6	Inelastic supply ε=0.5	10% increase in expected net yield and price gain	10% increase in maximum adoption rate	10% increase in time to maximum adoption
Experiment 1	Consumer	13,628,953	8,008,719	9,502,796	15,144,111	14,541,116	12,884,988
	Producer	10,903,162	12,813,951	15,204,473	12,115,289	11,632,893	10,307,990
	Total	24,532,115	20,822,670	24,707,269	27,259,399	26,174,009	23,192,978
Experiment 2	Consumer	3,352,091	2,065,224	2,394,964	3,828,298	3,688,242	3,264,604
	Producer	2,681,672	3,304,358	3,831,942	3,062,638	2,950,594	2,611,683
	Total	6,033,764	5,369,581	6,226,905	6,890,936	6,638,836	5,876,286
Experiment 3	Consumer	4,262,309	2,714,030	3,003,351	4,821,395	4,366,387	4,137,200
	Producer	3,409,846	4,342,449	4,805,362	3,857,116	3,493,109	3,309,760
	Total	7,672,155	7,056,479	7,808,713	8,678,511	7,859,496	7,446,959
Experiment 4	Consumer	8,329,025	4,817,235	5,979,056	9,481,635	9,005,756	7,898,158
	Producer	6,663,220	7,707,576	9,566,490	7,585,308	7,204,605	6,318,527
	Total	14,992,243	12,524,812	15,545,546	17,066,943	16,210,361	14,216,685
Experiment 1-4	Consumer	29,572,377	17,605,208	20,880,167	33,275,439	31,601,501	28,184,949
	Producer	23,657,901	28,168,333	33,408,267	26,620,351	25,281,201	22,547,960
	Total	53,230,277	45,773,542	54,288,433	59,895,789	56,882,702	50,732,909

similar magnitude to initial increase (10.6%) but did not affect the distribution of welfare effects much. The simulation with respect to a 10 percent increase in the time to maximum adoption of olive IPM packages generated a decrease of –4.7 per cent in total economic surplus benefits but distribution effects were not subject to change. The results of the sensitivity analysis indicate that the total benefits and their distribution to producers and consumers are quite sensitive to the size of supply and demand shifts, elasticity assumptions, time required to complete research, and rate and intensity of adoption.

5.4.6 Major findings

Simulation results indicate that the Albanian olive industry has the potential to derive a net IPM research benefit that varies between $39 million (assuming that farmers move directly from a situation with no spraying to IPM) and $52 million (assuming that farmers move from full pesticide program to the IPM program) over the next 30 years. Of this amount, $32.5 million (62%) are expected to come from research-induced olive yield gains and $19.75 million (38%) from quality improvement. The majority of expected benefits ($29 million or 55%) are concentrated in the research target zone and the rest ($23 million or 45%) are spillover effects to be realized in adjacent olive growing zones. Under each of the model specifications, consumers are the primary beneficiaries of olive IPM research because prices fall as additional olive oil supplies enter the domestic market each year. However, producers receive nearly half (45%) of the benefits from IPM research. The distribution of benefits to producers and consumers is sensitive to price elasticity of demand with higher elasticities benefiting producers relative to consumers. Finally, the cost benefit calculations indicate that the IPM CRSP/Albania research on olives not only covers research and development costs but also offers great efficiency gains.

The following policy implications can be drawn from the economic surplus analysis of IPM research on lives in Albania: (i) IPM CRSP/Albania program promises high rates of economic return to research investment on olives and the Albanian government should design and fund projects for IPM technology development and dissemination on olives; (ii) All four experiments are expected to generate positive net economic benefits to producers and consumers. However, the need for IPM research to develop a selective method for controlling olive fruit fly and olive moth that will be practical for farmers should be given the highest priority; (iii) Designing optimal weed and pest control strategies that involve a limited use of pesticides on olives reduces pesticide residue in olive products in Albania and therefore could help Albanian olive growers to be more competitive in the regional markets; and (iv) The IPM CRSP/Albania research program should be followed by a government funded dissemination program in order for the developed olive IPM packages to reach the end users, that is, olive growers in the target area as well as in other olive growing regions in Albania.

Section 5.5 Results of the Adoption Model

5.5.1 Sample characteristics

Descriptive statistics for the variables included in the two estimated logit models are presented in table 5.66. The final sample consisted of 198 and 121 olive growers for the baseline survey and follow-up surveys, respectively. The main sample characteristics from the baseline survey data were discussed in section 5.2 of this chapter. The 2000 data set, which appears in the second part of table 5.66, indicates that the estimated level of prospective olive IPM adoption is 43%. Mean values of the qualitative variables refer to the proportion of 121 olive growers responding to particular attributes in 2000. For instance, approximately 38% of respondents were aware of pesticide harmful effects on environment, 46% used pesticides on grapes, 23% used pesticides on olives, and 6% used pesticides on other fruit trees. Number of olive trees, farm size, age, experience, yield per tree and olive oil production per farm were included as continuous variables, farmers' perceptions were ranked from 1 to 5, and all other explanatory variables were included as dummies.

Correlation analysis among the independent variables was first run before setting up the final logit regression models. Examination of correlation coefficients suggested that both models are subject to some collinearity. For the 1999 data set, oil production (OILPROD) was highly correlated with olive oil sold

Table 5.66 Descriptive statistics of variables

Variable	Minimum	Maximum	Mean	Standard Deviation
1999 Data set				
DEPVAR	0	1	0.43	0.50
FMSZ	0.1	12.5	1.59	1.61
NOTR	8	200	56.51	36.89
FRAG	1	6	2.42	0.97
APHE	0	1	0.38	0.49
UPOFT	0	1	0.09	0.29
UPGR	0	1	0.46	0.50
UPOL	0	1	0.23	0.42
PRUN	0	1	0.75	0.43
TAUT	0	1	0.75	0.44
SPR	0	1	0.50	0.50
RTV	0	1	0.25	0.43
EXTS	0	1	0.52	0.50
PDLR	0	1	0.25	0.43
OFRM	0	1	0.41	0.49
AGE	16	80	49.29	12.28
EDU	0	5	0.83	1.02
EXP	5	20	16.65	4.60
OMIC	0	1	0.46	0.50
OILPROD	10	1500	326.92	268.92
OILSOLD	0	1300	190.53	244.79
YIELD	1.2	100	31.1	18.3
OFFARMW	0	6	0.83	1.12
2000 data set				
DEPVAR	0	1	0.68	0.47
IPMAWR	0	1	0.44	0.50
FMSZ	0.2	5	1.41	0.83
NOTR	12	220	62.09	44.22
FRAG	1	5	2.33	1.08
APHE	1	5	2.11	1.10
UPOFT	0	1	0.11	0.31
UPGR	0	1	0.82	0.39
UPOL	0	1	0.11	0.31
PRUN	0	1	0.93	0.26
TAUT	0	1	0.82	0.39
SPR	0	1	0.43	0.50
RTV	0	1	0.32	0.47
MGNSP	0	1	0.15	0.36
EXTS	0	1	0.60	0.49
PDLR	0	1	0.57	0.50
OFRM	0	1	0.43	0.50
AGE	24	82	52.52	11.52
EDU	1	5	3.39	0.91
EXP	4	60	27.07	13.1
OMIC	0	1	0.80	0.40
RISK	1	5	3.1	1.34

(OILSOLD, r=0.93), number of olive trees (NOTR, r=0.50), and YIELD (r=0.46). Also, AGE was highly correlated with experience in both data sets (EXP, r=0.57 and 0.70, respectively) and household size was correlated with NOTR (r=0.39). Therefore, variables AGE, HSDS, and OILPROD were eliminated from the model. In the 2000 data set, FRAG was highly correlated with NOTR (r=0.58), HSDS was correlated with HCAP (r=0.39), and MGNSP was correlated with RTV (r=0.38). For the same reason, variables FRAG, MGNSP, and HSDS were eliminated from the second model. Also, variables UPOFT and UPOL were excluded from both models because they contained too many zero responses. The final model estimated with the 1999 data set contained 18 independent variables and the model estimated with the 2000 data set contained 14 independent variables.

5.5.2 Estimation results

The results of the logit analysis for the non-chemical olive pest management model (NCPM) and willingness to adopt olive IPM model (WAIPM) are presented in tables 5.67-5.68. The NCPM model fitted with the 1999 data set has a log-likelihood value of 112.66 and the chi-squared value of 45.17, which is significant at 0.10 level[72]. The WAIPM model fitted with the 2000 data set has a log-likelihood value of 11.08 and the chi-squared value of 129.95, which is significant at 0.0001 level. The prediction rate (a goodness of fit measure, see Amemiya, 1981) for the NCPM model is 69.2%. This indicates that the model correctly classified olive growers with respect to adoption of non-chemical pest control measures approximately 69% of the time with 78.8% of potential non-adopters are correctly predicted. The predicted rate for potential adopters, however, was 56.5%. Similarly, the WAIPM correctly predicts potential adopters 95.1% of the time and potential non-adopters 89.7% of the time.

The only variables significant at the 1 percent level in the NCPM model are RTV and YIELD (Table 5.57). Farmers who watch TV and listen to radio are 27% more likely to adopt non-pesticide pest control practices. Also, farmers achieving higher yields per olive tree are much more likely to apply these

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[72] A brief discussion on the binary logit model and interpretation of its estimation results appears in Appendix F.

practices. NOTR was found to have a significant association with adoption of non-chemical practices at the 5% level indicating that a large number of trees owned by a farm increases probability of adoption by 33%. The coefficients of both PDLR and OILSOLD were found negative and statistically significant at the 10% level. As expected, as the number of contacts with pesticide dealers and the marketable surplus of olive oil increase, the probability that farmers adopt non-chemical practices decreases by 16% and 40%, respectively.

Table 5.67 Logit coefficient estimates of factors affecting use of non-chemical methods for controlling olive pests

Variable	***Coefficient***	***Standard Errors***	***t-ratio***	***Significance Level***	***Probability Effect***
ONE	-3.0471	1.0440	-2.9188	0.0035	
FMSZ	-0.2232	0.1495	-1.4935	0.1353	-0.5509
NOTR	0.0135	0.0066	2.0578	0.0396	0.3336
FRAG	-0.0833	0.1760	-0.4731	0.6362	-0.2055
APHE	-0.4190	0.3472	-1.2070	0.2274	-0.1034
UPGR	-0.1317	0.3549	-0.3709	0.7107	-0.3249
PRUN	0.5003	0.4968	1.0071	0.3139	0.1234
TAUT	0.4013	0.4719	0.8503	0.3951	0.9903
SPR	0.4072	0.3696	1.1016	0.2706	0.1004
RTV	1.0776	0.3962	2.7195	0.0065	0.2659
EXTS	0.4384	0.3450	1.2708	0.2038	0.1082
PDLR	-0.6788	0.3986	-1.7030	0.0886	-0.1675
OFRM	-0.4560	0.3678	-1.2398	0.2150	-0.1125
EDUC	0.2515	0.1738	1.4470	0.1479	0.6206
EXP	0.0285	0.0387	0.7379	0.4606	-0.7042
OMIC	0.4369	0.3585	1.2188	0.2229	0.1078
OILSOLD	-0.0016	0.0010	-1.6358	0.1019	-0.4066
YIELD	0.0379	0.0130	2.9013	0.0037	0.9344
OFFFARMW	-0.1343	0.1623	-0.8275	0.4079	-0.3314

```
| Maximum Likelihood Estimates                    |
| Number of observations              198         |
| Log likelihood function       -112.6672         |
| Restricted log likelihood     -135.2567         |
| Chi-squared                    45.17889         |
| Significance level             .1043464E-02     |
```

Predicted				*Percent*	
------	----------	+	-----	*correct*	
Actual	0	1	| Total		
------	----------	+	-----		
0	89	24	| 113	*78.8*	non-adopters
1	37	48	| 85	*56.5*	adopters
------	----------	+	-----		
Total	125	73	| 198	*69.2*	

Other variables of interest significant at the 20% level are EDU, FMSZ, EXTS. A high level of education of household members increases the probability of adoption by 62%. Contrary to expectations, large farms were found to be less likely to adopt the non-chemical practices. Farmers' contacts with extension specialists increase probability of adoption by approximately 11%. Farmers' awareness of pesticide harmful effects on human health and environment is not found to enhance adoption and has a significance level of 22%. The management practice variables such as use of pesticides on grapes, olives, and other fruit trees as well as the sprayer ownership were not statistically significant. This implies that application of other pest control tactics may not necessarily affect farmers' decision to adopt olive IPM. Off farm employment and ranking of olive as major source of income are not statistically significant either.

The results from the logit analysis of farmers' willingness to adopt olive IPM practices indicate that the likelihood of adoption of these practices is enhanced by EDU, NOTR, FMSZ, and IPMAWR (Table 5.68). The probability of olive IPM adoption is reduced by UPGR, SPR, PDLR, and RISK. The variable PDLR is statistically significant at the 1 percent level. Variables RISK, EDU, SPR, and IPMAWR were significant at the 5% level. Significant at the 10% level are FMSZ and NOTR. Other variables of interest that are significant at 20% level are EXTS, RTV, and OMIC. The estimated coefficients on EDU, IPMAWR, EXTS, and RTV are positive and provide further evidence that educational and informational variables play a key role in increasing the probability of IPM adoption by farmers. As hypothesized, the negative sign of the PDLR variable suggests that use of pesticide dealers by farmers as a source of pest management information reduces the likelihood of olive IPM adoption.

Producer's opinion on the production and price risk associated with olive IPM practices is an important determinant of the likelihood that the adoption of olive IPM take place at the farm level. Respondents who reported that yield risk is a significant problem associated with IPM are 15% less likely to adopt olive IPM. Risk perception of IPM revealed by a number of respondents may contain elements of their attitude towards risk. Separating the effects of risk perception and risk attitudes may prove difficult even if data on the respondents' attitudes toward risk were available. However, the negative sign of coefficient of the risk variable is in line with what other studies have previously found in the case of IPM technologies. For instance, Haneman and Farnsworth (1981, p. 19) in a study carried out on this topic concluded that "…the most plausible explanation of why some of them [farmers] employ IPM and others use conventional control is not differences in risk aversion nor the use of some decision criterion other than expected utility maximization but, rather, systematic differences in their perceptions of the outcomes associated with IPM versus conventional control.”

Table 5.68 Logit coefficient estimates of factors affecting farmers' willingeness to adopt olive IPM practices

Variable	Coefficient	Standard Errors	t-values	Significance Level	Probability Effect
ONE	-3.1103	5.7607	-0.5399	0.5893	
IPMAWR	8.4249	3.9680	2.1232	0.0337	0.3439
FMSZ	2.1170	1.1924	1.7754	0.0758	0.8642
NOTR	0.0645	0.0393	1.6412	0.1008	0.2634
APHE	0.9096	0.9323	0.9756	0.3293	0.3713
UPGR	-4.3179	2.3622	-1.8279	0.0676	-0.1762
SPR	-13.0163	6.0501	-2.1514	0.0314	-0.5313
RTV	0.2284	0.1458	1.6653	0.1274	0.1299
EXTS	0.4809	0.3059	1.5723	0.1159	0.1963
PDLR	-9.3776	3.7687	-2.4883	0.0128	-0.3828
OFRM	2.3764	1.9471	1.2205	0.2223	0.9701
EDU	5.0549	2.3817	2.1224	0.0338	0.2063
EXP	-0.0589	0.0707	-0.8341	0.4042	-0.2406
OMIC	2.4583	1.8300	1.3433	0.1792	0.1003
RISK	-3.7160	1.6234	-2.2890	0.0221	-0.1516

```
| Maximum Likelihood Estimates                 |
| Number of observations              121      |
| Log likelihood function        -11.08121     |
| Restricted log likelihood      -76.06077     |
| Chi-squared                     129.9591     |
| Significance level              .0000001     |
```

	Predicted			Percent	
Actual	0	1	Total	correct	
0	35	4	39	*89.7*	potential non-adopters
1	4	78	82	*95.1*	potential adopters
Total	37	84	121	*91.9*	

5.5.3 Policy implications

From a statistical point of view, the estimated results of the two logit models described above are incomparable even though the explanatory variables are similar. This is because the joint and conditional distributions of both models were derived from two different identically and independently distributed samples. Nevertheless, some common policy prescriptions can be formulated based on these two sets of results. The significant producer characteristics were education, IPM awareness, and perception about IPM risk. The first two variables revealed positive influence and the last one negative influence on the likelihood of olive IPM adoption. The farm structure variables that were statistically significant were farm size, number of olive trees, yields, olive oil sold, and ranking of olives as a major source of income. Farm size is inconsistent in sign indicating negative influences in the first model and positive influences in the second model. In fact, for the case of olive IPM, the number of olive trees variable represents the scale of operations better than the amount of land owned by farmers because olive trees are relatively more important as a capital value than land itself in terms of olive production. The fact that farmers with a large number of olive trees are more willing to adopt olive IPM implies that special IPM training programs should be designed targeting groups of farmers with different access to resources. Equally important is demonstrating the merits of IPM over the conventional control in terms of economic, environmental, and health benefits to producers, consumers and society as whole.

The lack of statistical significance associated with most management practice variables considered in this study does not support the hypothesis that IPM adoption on olives is influenced by farmers' use of pesticides in other fruit trees, especially on grapes. Therefore, farmers' tendency for heavy use of pesticides in other crops is not expected to serve as a hindrance to olive IPM adoption. This finding reinforces similar evidence presented by Katsoyannos (1992) with respect to factors influencing olive IPM adoption in other Mediterranean countries. Even though the spraying of grapes variable was found to negatively influence probability of olive IPM adoption, this effect is not unduly damaging because, as was explained in section 5.2 of this chapter, there are cultural influences and differing set of perceptions in addition to economic considerations with respect to pest management practices applied on grapes versus olives by Albanian farmers. Finally, both specified logit models revealed the high statistical significance of the pest management informational factors in influencing farmers' future decisions on IPM adoption. Extension specialists and radio and TV programs are expected to play a key role in olive IPM adoption. On the other hand, pesticide dealers will continue to exert pressure on farmers for increasing use of pesticides for controlling olive pests. The implication is that greater attention should be given to the design and implementation of education and extension programs that: (i) increase farmers' awareness of environmental problems associated with pesticide use and the role of IPM as an alternative sustainable strategy for pest control; and (ii) influence the process of expectation formation with respect to IPM.

Section 5.6 Concluding Remarks

This chapter presented results of the 1999 baseline survey, partial budget and economic surplus analysis of olive IPM practices as well as the estimates of adoption models. The results of the baseline survey identified the group of socio-economic factors that influence pest perceptions, pest management practices and potential constraints to IPM adoption. Partial budget analysis evaluated the alternative IPM strategies to determine which ones are economically feasible in terms of yield and quality gains and/or savings with respect to a reduction in pesticide use or other inputs. Results of various simulations designed to evaluate the potential market-level economic impacts (benefits to producers, consumers, and the country as a whole) from IPM research on olives were presented in the fourth section. Based on the economic surplus equilibrium displacement model for the Albanian olive market developed in Chapter 3, the prices, quantities, and present value of economic surpluses were simulated for each experiment across olive producing zones and for each scenario of interest. The simulation results were summarized into aggregate measures for the whole IPM research program. Finally, the dichotomous logit analysis identified the role of risk perceptions, information, and other socio-economic factors on the prospects for adoption of olive IPM by olive growers. Major findings and policy implications were highlighted in each section.

Chapter 6: Conclusions

6.1 Introduction

This chapter summarizes the main components of the dissertation and presents conclusions and policy implications in the light of the results discussed in the previous chapter. It also highlights the study's limitations and provides suggestions for further research.

6.2 Summary of the dissertation

Concerns about the harmful effects of pesticides on the environment, human health, and wildlife have led to research and promotion of integrated pest management strategies. IPM is a knowledge and information intensive approach to pest control with sound social, ecological, and economic foundations. Recently, an IPM program was introduced in the Albanian olive sector through the USAID-funded global IPM-CRSP project to develop improved olive IPM technologies that reduce crop losses; increase farm income; minimize pesticide use; and increase farmers' understanding, knowledge, and skills on pest management.

This dissertation has focused on the economic impact assessment of olive pest management strategies developed and tested by the IPM-CRSP/Albania project in Vlora district, Albania. The IPM research on olives is expected to increase yield and/or decrease cost, reduce risk and future pesticide use as well as improve quality of olive products, especially olive oil. An IPM research-induced reduction in olive oil acidity and in pesticide residues, among other things, improves characteristics of olive products and could eventually increase demand for high valued products. The development, implementation, and adoption of IPM programs involve investment of scarce resources in the production of knowledge. Increasing the stock of knowledge and information on olive IPM can lead to an increase in productivity and thereby contribute to a range of economic and social objectives, especially economic efficiency and equity.

This study is important to Albania because production and income losses resulting from various pests are presently high on all agricultural crops, including olives. The research questions addressed in this dissertation include: (i) Do the tested olive IPM practices increase income, reduce pesticide use, and/or lower the costs compared to conventional methods of pest control? (ii) Do the olive IPM strategies provide enough economic benefits to society as to be institutionalized as a national strategy for crop protection? (iii) What are the major factors and barriers that affect the prospects of farmer adoption of IPM practices and what kind of knowledge base and information system are needed to support the implementation of IPM practices?

The need for developing protocols for integrated impact assessment of IPM programs has been widely recognized. The results obtained from any favorable evaluation of production costs and potential profits may be instrumental in convincing growers to adopt new IPM technologies. Knowledge regarding potential aggregate social benefits of IPM adoption is necessary for informing national policy makers and research directors of the overall merits of IPM strategies and their economy-wide impacts. The assessment of IPM impacts also helps the process of planning and priority setting in agricultural research.

The main objective of this dissertation has been to develop and apply a system for integrated assessment of the potential farm-level and country-wide economic impacts of olive IPM CRSP research in Albania. Specific objectives include: (i) assessment of the potential impacts of olive IPM practices on the level of net returns to farmers; (ii) estimation of the potential aggregate economic impacts of olive IPM programs for producers, consumers, and the country as a whole; and (iii) examination of the effects of farmers' perceived risk of IPM and other economic, social, and informational factors on the prospects for adoption of IPM practices by olive growers.

Chapter 2 provided a critical review of previous research carried out on economic impact assessment of IPM programs, major models of farmers' decision-making processes in pest management, primary techniques used for IPM assessment, and the common approaches employed for evaluating IPM adoption. The review of literature revealed a limited number of studies related to evaluation of aggregate economic and environmental impacts of IPM in general and the absence of such studies on olive IPM. This review suggested that more rigorous methodological frameworks and protocols are needed for economic impact assessment of IPM. Evaluation of welfare effects from research-induced supply shifts has received considerable attention. Less attention, however, has been devoted to the assessment of research directed at quality improvement. No study has assessed the market impacts of quality-improving IPM research, and only a few studies have assessed research benefits by examining simultaneous shifts in supply and demand. Finally, a number of models, methods and techniques that are available for economic impact assessment of IPM were examined in terms of data requirements, degree of detail and sophistication, analytical capacity required, outputs, the rigor of results, and transparency of calculations. Among the group of formal quantitative methods, economic surplus analysis was chosen for this study as a method that uses economic-based information and a consistent economic framework.

Chapter 3 presented the conceptual framework for this study based on the relevant theory of production and welfare economics. The main components of the integrated approach for economic impact assessment of olive IPM included: (i) net return analysis for measuring farm level impacts; (ii) economic surplus modeling for measuring market-level impacts; and (iii) modeling of IPM adoption under output uncertainty. An economic surplus equilibrium displacement model for the Albanian olive market with no international trade was developed to estimate the size and distribution of economic benefits from olive IPM-CRSP research. The model accounts for IPM research-induced supply shifts, increased demand due to quality improvement, and research-induced spillovers to non-target zones.

The assessment was performed spatially as well as thematically in accordance with the site-specific and integrated nature of IPM research. Uncertainty related to research outcomes and adoption profiles over time for each research theme was accounted for in the elicitation process of research potential. Research outcomes were assumed to follow a triangular probability distribution with yield and quality gains specified in terms of minimum, most likely, and maximum possible outcomes. The likely olive IPM adoption profile was assumed to have a non-symmetric trapezoidal lag structure.

A behavioral model of adoption under output uncertainty was developed to estimate the influence of farmers' perceived risk of IPM and other socio-economic factors on the likely rate of olive IPM adoption. The model was formulated as a portfolio problem in which growers allocate farm resources (the number of olive trees) between a known production system with conventional pest control (CPC) strategies and an alternative stochastic production system represented by IPM strategies.

Chapter 4 described the process of economic impact assessment of olive IPM consistent with the conceptual framework developed in chapter 3. The empirical model was specified through several steps. First, the setting for the evaluation exercise including the olive IPM research objectives, major research themes, evaluation scenarios, and agro-ecological zones was defined. Second, the technology generation and adoption parameters (yield and quality gains, dissemination thresholds, probability of research success, research development lag, and adoption profile), market-related data (quantities, prices, elasticities, and discount rate) and research costs were specified. Third, major variables included in the logit model of IPM adoption and data employed for model estimation were discussed. Finally, Excel was used to incorporate technology generation data, market-related data, and economic formulas into spreadsheet templates to calculate farm-level and market-level economic impacts of olive IPM research. The logit model of adoption was estimated using the software package LIMDEP.

The main sources of data for performing economic surplus analysis were: (i) an expert survey; (ii) partial budgets compiled based on a farmer survey and expenditure records from field-level experiments; and (iii) data collected at the market level. The data used to estimate the dichotomous logit model came from a baseline survey of 200 growers and a cross-section survey of 120 growers carried out in the Vlora district of Albania in the summer of 1999 and 2000, respectively.

The results obtained were reported in Chapter 5. Major conclusions and policy implications derived from those results are summarized in the following section.

6.3 Conclusions

The baseline survey results revealed that farmers have limited knowledge about olive pests, their natural enemies, and pest management practices. Information on pest control methods is virtually non-existent. Research and extension have poor links with farmers. Although extension and department of agriculture specialists are highly regarded as reliable sources of information by farmers, farmers' contact with these sources is relatively infrequent. Often, pesticide dealer advice serves as the only alternative to farmers' own experience with respect to pest management. The role of information is crucial to IPM implementation and adoption. Farmers' limited knowledge and information base suggests that IPM training courses, field-level demonstrations, and the extensive use of mass media are needed to improve their understanding and knowledge of pests as well as their managerial skills, increase their awareness of harmful effects of pesticides, and promote IPM dissemination.

Mobility of some of the olive pests necessitates an area-wide control. The area wide control, in turn, requires an area wide adoption of IPM practices associated with those mobile pests. Olive grove fragmentation, which is widely present in the study area, makes it difficult to achieve the area-wide adoption of IPM. There are two alternatives to the amelioration of the effects of fragmentation and pest mobility on adoption: (i) promotion of farmers' collective action with respect to control of certain mobile olive pests and (ii) consolidation of olive groves through the process of olive tree redistribution. The latter might prove more difficult than the former because it is essentially a mini land reform and requires wide political support that stretches beyond a village community.

The proposed olive IPM packages are expected to be more profitable than both the current farmer practices involving limited pesticide use and potential future pesticide-based pest control practices. These alternative IPM practices generally promise higher yields, improved quality of olive products, lower pesticide use, and higher net returns to producers. However, under both scenarios, that is, for growers who move directly from an olive production system with minimum spraying to an IPM program or from full pesticide program to IPM, adoption of some of the IPM practices including vegetation management, pruning/copper treatment, and pheromone/olive fly strategies implies higher production costs. Under the full pesticide scenario, the pesticide reduction associated with olive IPM is to 50%. Compared to the minimum practice scenario, which represents current conditions, the pruning/copper treatment strategy involves an increase in pesticide use.

The economic surplus analysis indicated that the IPM CRSP/Albania research on olives not only covers research and development costs but also offers great efficiency gains. All four olive IPM packages considered are expected to generate positive net economic benefits to producers, consumers, and the country as a whole. However, IPM research should develop a selective method for controlling olive fruit fly and olive moth that is practical for farmers. The promising high rates of economic returns to the research investment of the IPM CRSP/Albania program on olives imply that the Albanian government should design and fund projects for IPM technology development and dissemination on olives and perhaps on other crops as well.

Designing optimal weed and pest control strategies that involve a limited use of pesticides on olives reduces pesticide residues in olive products in Albania and therefore might help Albanian olive growers to be more competitive in the regional markets. A complicating factor at present is a lack of differentiation in prices between olives infested with olive fruit fly, and high quality fruit. This lack of differentiation will need to be addressed to economically justify IPM actions by farmers. Introduction and enforcement of grades and standards for olive products and especially for olive oil is needed to capture the IPM-research induced improvement in quality of olive products. Finally, in order to fully reap the benefits of olive IPM research, the country’s Ministry of Agriculture has to come up with an appropriate IPM policy. This IPM policy should include not only future plans for IPM research and development, but also a detailed dissemination program of olive IPM packages. That is, an IPM technology dissemination program with clear responsibilities for extension and research institutions and relevant financial arrangements should follow the IPM CRSP/Albania project, if the developed IPM packages are to reach the olive growers.

The results from a dichotomous logit model showed that potential IPM adopters compared to those unwilling to adopt are more likely to be better educated, operate farms with large number of olive trees, achieve higher yields per olive tree, be better informed about IPM, meet more often with extension agents, watch agriculture-related TV programs, and perceive IPM as less risky. Farmers' reliance on pesticide use on olives and other crops does not seem to hinder IPM adoption. Perceived risk and informational factors play an important role in IPM adoption. The implication is that grower perceptions and the process of expectation formation significantly influence adoption decisions. Addressing the process of expectation formation and changing these perceptions by educational programs and better access to information will encourage IPM adoption. Subsidy programs that reduce the cost of acquiring information through public programs of scouting and monitoring services may be helpful in enhancing IPM adoption.

6.4 Implications for future research

This dissertation has provided a protocol for *ex*-ante economic impact assessment of olive IPM. With some slight modifications, the methods can easily be applied for evaluating IPM and other research programs to various crops in Albania and/or elsewhere in developing countries. This research may thus pave the way for future impact assessment studies. The process followed for economic impact assessment of olive IPM research uses economic-based information, considers yield and quality gains, is transparent, and consistent with the relevant theory of production and welfare economics.

The economic surplus model applied to estimate the future economic benefits from the IPM research program was developed under a partial equilibrium framework. As such, it captures research-induced welfare effects in olive product markets only, ignoring any effect of changes in other product and factor markets in the economy. It is likely that these other effects in factor markets are small given the limited use of pesticides by olive growers. However, it is of interest to know how the IPM research-induced increase in supply of olive oil will affect the market of other edible oils within the country.

In the absence of joint adoption rates, the NPV for the whole IPM program was derived as a simple sum of the results of the separate displacements of welfare effects for each of the four current research themes based on their respective partial adoption rates. It was presumed that the errors from ignoring interaction effects among research themes might be small. Because of the aggregation, the economic surplus results might be overstated. If the results are overstated, in order to obtain better approximation of the NPV for the whole research program involving many research themes, estimates of net benefits could be based on both joint and partial adoption rates. Then one could either conduct one omnibus benefit-cost assessment of this joint scenario or add up the results from the five elements of the scenario, that is, one per theme. On the other hand, if synergistic relationships exist among the practices, the benefits might be understated.

The estimates of IPM research benefits are sensitive to underlying assumptions of the economic surplus model. This study assumed a parallel supply shift implying similar cost reductions for low-cost and high-cost producers. Although, this assumption might be appropriate for this case, a pivotal supply shift should be considered as well when low-cost and high-cost producers constitute distinct groups. Also, in the absence of information on price elasticities of supply and demand for olive products, elasticity assumptions were based on economic theory only. Rates of return to each research theme may be underestimated because the future new planting of olive trees was not included in the analysis. The current new plantings are very limited in the study area, but eventually more plantings are expected.

The lack of consistent and reliable statistical information on olive production and other economic indicators was a pressing issue for this dissertation. Data limitations are a continuous problem in developing countries, but when it comes to Albania this issue is very serious. Almost all data used in this study were generated from primary sources because data from secondary sources were either nonexistent or unreliable. Due to lack of historical olive yield statistics by zones, this study used the same yield level as a baseline for all three zones. In that regard, the accuracy of spatial distribution of IPM research benefits might have been affected. Also, no olive enterprise budgets were available. Despite the triangulation approach used in this study in compiling total budgets for each scenario considered, certain elements of costs might be overstated or understated. Therefore, research and extension agencies need to improve the system of monitoring and evaluation for field level experiments and frequently carry out economic feasibility studies for major enterprises.

Finally and most important, the accuracy of parameters related to potential technology generation and adoption greatly affects the size and accuracy of economic surplus estimates. The process of eliciting these parameters through expert interviews is crucial to insuring accurate estimates of these parameters. Even under a well-designed expert survey, the *ex-ante* evaluation results are far from being free of experts' value judgments, vested interests, and other possible biases. Researchers should make maximum efforts to assure that experts interviewed have a clear understanding of the general agricultural systems and the subject matter about which they are asked to provide subjective estimates. Additional research is needed with respect to the elicitation process especially when there are multiple experts with different opinions for a given issue. Other related issues include: what to do when there are legitimate differences of opinion among experts and does the interaction among the groups of experts improve elicitation and if so what kind of interaction should be encouraged.

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Appendix

Appendix A

The effects of perceived risk and risk attitudes on IPM adoption

The optimal choices derived from the analytical model of adoption presented in section 3.5 (Chapter 3) do not explicitly show the role the farmers' perceived risk of olive IPM and their risk attitudes play in adoption decisions. The effects of these factors can be more clearly stated by using an expected value-variance (EV) model instead of the expected utility model. The EV model considers the expected utility solutions in terms of their expected values (E) and variances (V). Robison and Barry (1987) showed that maximizing the expected utility of a choice from an EV efficient set under certain conditions is equivalent to maximizing the certainty equivalent of the choice[73]. Referring to the same initial portfolio problem in which the olive grower must allocate the number of olive trees between a safe and a risky pest control strategy, the expected income is[74]:

$$E(Y) = (R_N + e)T_N + R_C(T - T_N) \qquad \text{(A.1)}$$

and variance of income is:

$$\sigma^2(Y) = T_N^2 \sigma_e^2 \qquad \text{(A.2)}$$

Following Robison and Barry (1987) the certainty equivalent income model can be written as:

$$\max \quad Y_{CE} = (R_N + e)T_N + R_C(T - T_C) - \frac{\lambda}{2} T_N^2 \sigma_e^2 \qquad \text{(A.3)}$$

---

[73] Description of the EV model and the sufficient and necessary condition (s) required for the EV model to provide the same ordering of risky prospects as a more general EU model can be found in Meyer (1987).

[74] As noted above, the per unit return $R_N + e$ obtained from trees exposed to IPM is a random variable having a mean of zero and variance σ_e^2.

where Y_{CE} is the certainty equivalent of income[75], that is, the return obtained from the risk free pest control strategy that gives the same level of utility as the risky pest control strategy and λ is the Pratt absolute risk aversion coefficient.

Taking the first derivative of (A.3) with respect to T_N and solving for T_N yields the optimal number of olive trees to be exposed to the IPM:

$$T_N^* = \frac{R_N - R_C}{l\, s_e^2} \qquad for \quad 0 \le T_N \le T \tag{A.4}$$

Expression (A.4) shows that the IPM adoption ($T_N > 0$) does occur if the expected return with the new IPM strategy exceeds the safe return under the CPC strategy. Taking derivatives of the optimal value given by (A.4) with respect to risk aversion coefficient, l, and the perceived risk of the IPM strategies, s_e^2, yields the following comparative static results:

$$\frac{dT_N^*}{dl} = \frac{-(R_N - R_C)}{l^2 s_e^2} < 0 \tag{A.5}$$

$$\frac{dT_N^*}{ds_e^2} = \frac{-(R_N - R_C)}{l^2 (s_e^2)^2} - \frac{(R_N - R_C)}{s_e^2 l^2} (\partial l / \partial s_e^2) < 0 \tag{A.6}$$

The expressions (A.5) and (A.6) show that the intensity of IPM adoption (T_N) is reduced by an increase in risk aversion or by an increase in the perceived riskiness of the IPM strategies. The equations (A.5) and (A.6) hold at least for constant absolute risk aversion (CARA) producers and decreasing absolute risk aversion (DARA) producers (Robison and Barry, 1987)[76].

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[75] The certainty equivalent equals the expected returns on the risky pest control strategy less the risk premium.

[76] $(\partial l / \partial s_e^2) > 0$ for DARA decision makers and zero for CARA decision makers.

Appendix B

Deriving formulas 3.54-3.55 (Chapter 3)

Changes in welfare measures due to demand shift only:

Figure 3.5

$$CS_0 = F_0AP_0 \qquad CS_1 = F_1A'P_0'$$

$$PS_0 = P_0AE_0 \qquad PS_1 = P_0'A'E_0$$

$$TS_0 = F_0AE_0 \qquad TS_1 = F_1A'E_0$$

$$\Delta_D CS = F_1A'P_0' - F_0AP_0 = F_1A'GF_0 - P_0'GAP_0$$

$$\Delta_D PS = P_0'A'E_0 - P_0AE_0 = P_0'A'AP_0 = P_0'GAP_0 + GA'A$$

$$\Delta_D TS = F_1A'GF_0 + GA'A = F_1A'AF_0$$

$$equivalent \quad to \quad (TS_1 - TS_0) = F_1A'E_0 - F_0AE_0 = F_1A'AF_0$$

Changes in welfare measures due to supply shift after demand shift occurs:

Figure 3.6

$$CS_0 = F_1A'P_0' \qquad CS_1 = F_1B'P_1'$$

$$PS_0 = P_0'A'E_0 \qquad PS_1 = P_1'B'E_1$$

$$TS_0 = F_1A'E_0 \qquad TS_1 = F_1B'E_1$$

$$\Delta_{S/D} CS = F_1B'P_1' - F_1A'P_0' = P_0'A'B'P_1'$$

$$\Delta_{S/D} PS = P_1'B'E_1 - P_0'A'E_0 = P_1'B'E_1 - D'C'E_1 = P_1'B'C'D' \qquad (\Delta P_0'A'E_0 = \Delta D'C'E_1)$$

$$\Delta_{S/D} TS = P_0'A'B'P_1' + P_1'B'C'D' = P_0'A'B'C'D'$$

$$equivalent \quad to \quad (TS_1 - TS_0) = F_1B'E_1 - F_1A'E_0 = E_1E_0A'B'$$

Total changes in welfare measures due to supply and demand shift:

$$\Delta TS = \Delta_D TS + \Delta_{S/D} TS = F_1A'AF_0 + E_1E_0A'B' = F_1A'B'E_1E_0AF_0$$

Formulas for calculating changes in consumer and producer surplus due to a research induced simultaneous change in yield and product quality (referring to Figure 3.6, Chapter 3):

$$\Delta CS = (P_0^{'} - P_1^{'})Q_0^{'} + \frac{1}{2}(P_0^{'} - P_1^{'})(Q_1^{'} - Q_0^{'})$$

$$\Delta PS = (P_1^{'} - D^{'})Q_0^{'} + \frac{1}{2}(P_1^{'} - D^{'})(Q_1^{'} - Q_0^{'})$$

$$\left| \begin{array}{l} k = P_0 - D = P_0^{'} - D^{'} \\ G = P_1^{'} - D^{'} \\ \\ (P_1^{'} - D^{'}) = (P_0^{'} - D^{'}) - (P_0^{'} - P_1^{'}) = KP_0^{'} - ZP_0^{'} \\ \\ \dfrac{Q_1^{'} - Q_0^{'}}{Q_0^{'}} = Zh \\ \\ \dfrac{-(P_1^{'} - P_0^{'})}{P_0^{'}} = Z = \dfrac{Ke}{e + h} \end{array} \right\rangle$$

$$\Delta CS = ZP_0^{'}Q_0^{'}(1 + 0.5Zh)$$

$$\Delta PS = P_0^{'}Q_0^{'}(K - Z)(1 + 0.5Zh)$$

Computing $P_0^{'}$ *and* $Q_0^{'}$ **:**

Given:

g = vertical shift in demand curve expressed as price difference.

$Q_s = a + bP$

$Q_d = g_0 - dP_0$

$Q_d^{'} = g_0^{'} - dP_0^{'}$

At equilibrium:

$Q_s = Q_d$ *and* $Q_s = Q_{d'}$

Initial equilibrium price:

$$a + bP = g_0 - dP_0 \qquad \Rightarrow \qquad P_0 = \frac{g_0 - a}{b + d}$$

<u>"After demand shift" equilibrium price:</u>

$$a + bP = g_0^{'} - dP_0^{'} \qquad \Rightarrow \qquad P_0^{'} = \frac{g_0^{'} - a}{b + d} \qquad \Rightarrow \qquad P_0^{'} = P_0\left(1 + \frac{\frac{g}{Q_0}}{e + ?}\right)$$

Change in price:

$$P_0^{'} - P_0 = \frac{g_0^{'} - a}{b + d} - \frac{g_0 - a}{b + d} = \frac{g_0^{'} - g_0}{b + d} \qquad \text{denote} \quad g_0^{'} - g_0 = g$$

$$= \frac{g}{(b + d)} \qquad \text{multiply both} \quad \text{sides} \quad \text{by} \quad P_0 / Q_0$$

$$= \frac{g\frac{P_0}{Q_0}}{e + h}$$

$$P_0^{'} = P_0 + \frac{g\frac{P_0}{Q_0}}{e + h} \qquad \Rightarrow \qquad P_0^{'} = P_0\left(1 + \frac{\frac{g}{Q_0}}{e + h}\right)$$

"After demand shift" equilibrium quantity:

$$Q_0^{'} = Q_0 + g - \frac{gh}{e+h}$$

Change in quantity:

$$Q_0^{'} - Q_0 = (g_0^{'} - dP_0^{'}) - (g_0 - dP_0)$$

$$= \quad g_0^{'} - g_0 - d(P_0^{'} - P_0)$$

$$= \quad g - d(P_0^{'} - P_0)$$

$$= \quad g - \left(d\,\frac{g\,\frac{P_0}{Q_0}}{e+h} \right) \qquad = g - \frac{\frac{\Delta Q}{\Delta P}\frac{P_0}{Q_0}g}{e+h}$$

$$\Rightarrow \quad Q_0^{'} = Q_0 + g - \frac{gh}{e+h}$$

Appendix C

IPM CRSP / Albania Project

Baseline Survey

(Olive Production in Albania)

Interview Questionnaire

Household no. ________________ **Date of Interview** _______________
Respondent ________________ **Interviewer** _______________
Village ________________ **Commune** _______________

I. Background Information on Olive Production

1. What is your current farm size? | 11 | | ha

2. How many olive trees do you have on your farm? | 12 | | trees
Of which:

1)How many table olive varieties: | 13 | | trees
2)How many oil varieties: | 14 | | trees
3)How many mixed varieties: | 15 | | trees

3. In how many places are your olive trees located? | 16 | |

4. When were the olive trees privately distributed? | 17 | |
____1) 1991
____2) 1992
____3) 1993
____4) 1994
____5) 1995

5. How were the olive trees distributed? | 18 | |
____1) According to the law (on a per capita basis)
____2) According to the original ownership
____3) Other ways (specify)__________________

6. Have you planted any olive seedlings since you took over the olive trees? | 19 | |
____1)Yes ____2)No

6a. <u>If Yes</u>, how many seedlings did you plant? | 110 | |

7. What month did you plant olive seedlings? | 111 | |
____1) December
____2) January
____3) February
____4) Others (specify)_________________________

8. What is your source of olive seedlings?
(Check all that apply)
____1) Private sector grower
____2) Department of agriculture
____3) Research institute
____4) Self
____5) Friend/neighbor
____6) Traders
____7) Others (specify)_________________________

112	
113	
114	
115	
116	
117	
118	

9. What olive varieties do you grow on your farm?

____1) Kalinjot
____2) Pula Zeqin
____3) Frantoju
____4) Wild
____5) Others (Specify)__________________
____6) _________________________________
____7) _________________________________

119	
120	
121	
122	
123	
124	
125	

10. For your fruit trees, other than olives, last year, please provide the following information:

Crop	**No. Trees**		**Production (kilo)**		**Consumed (kilo)**		**Sold (kilo)**	
Fruit Trees	126		129		132		135	
Citrus	127		130		133		136	
Vineyard (ha)	128		131		134		137	

10a. Did you use pesticides in fruit trees last year?
(Check all that apply)
a. Fruit Trees ___1) Yes ___2) No
b. Citrus ___1) Yes ___2) No
c. Vineyards ___1) Yes ___2) No

138	
139	
140	

II. Pest Management Decision Making Within the Household

11. In your household, who decides how much money to spend on pesticides?
(Check all that apply)
____1) Male Farmer/brother/father
____2) Woman Farmer/sister/mother
____3) Both husband and wife
____4) Others (specify)_____________________________

21	
22	
23	
24	

12. Who buys the pesticides ?
(Check all that apply)
____1) Male Farmer/brother/father
____2) Woman Farmer/sister/mother
____3) Both husband and wife
____4) Others (specify)_____________________________

25	
26	
27	
28	

13. When pest problems occur, who decides what to do in the family?
(Check all that apply)
____1) Male Farmer/brother/father
____2) Woman Farmer/sister/mother
____3) Both husband and wife
____4) Others (specify)_____________________________

29	
210	
211	
212	

14. In your household, who decides what and where to market your products?
(Check all that apply)
____1) Male Farmer/brother/father
____2) Woman Farmer/sister/mother
____3) Both husband and wife
____4) Others (specify)_____________________________

213	
214	
215	
216	

III. **Factors Affecting Pesticide Use**

15. For your olives last year, please provide the following information?

Products	Production (kilo)		Consumed (kilo)		Processed (kilo)		Sold (kilo)		Price (lek/kilo)		Sale Income (lek)	
Olive	31		33		35		36		38		310	
Olive oil	32		34		▨		37		39		311	

16. What was your olive yield last season?

312		kilo/olive tree

17. Where did you process the olive oil?
(check all that apply)
____1) Home
____2) Factory
____3) Other (specify)_________________________

313	
314	
315	

18. Are there olive oil processing factories in your village?
____1)Yes ____2)No

316	

18a. <u>If YES</u>, how many factories are there in your village?

317	

19. Does the number and processing capacity of such factories meet the demand of all farmers in your village for processing olives?
____1)Yes ____ 2)No

318	

20. How far is the processing factory from your farm?

319		km

21. How much did you spend for transporting olives last year?

1) From olive blocks to your house:	320		lek/100 kilo
2) From your house to factory:	321		lek/100 kilo

22. How many hours did you spend getting to and from the market while selling olives?

322		hours

23. How much did you spend for processing olives in the factory?

323		lek/100 kilo

24. To whom (where) did you sell your table olives and olive oil?
(Check all that apply)
____1) Local trader
____2) Local market
____3) Non-local market
____4) Trade association
____5) Olive processors
____6) Other (specify)__________________________

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25. What are the problems you have for marketing your olive production?
(Check all that apply)
____1) Have nothing to sell
____2) Prices are low
____3) Market is far away
____4) Don't have vehicle for transportation
____5) Price of transport is unaffordable
____6) Don't know how to do standardization, packing & advertising
____7) There are no local collection points
____8) There are no markets
____9) Don't have any problem

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26. How much did you spend on pesticides (insecticides, fungicides, and herbicides)

1) For fruit trees? 339 ______ lek
2) For Olives? 340 ______ lek

27. How important were the following factors to your choices of pesticides (insecticides, fungicides, and herbicides) for your crops?

		Not Important		**Somewhat Important**		**Very Important**		**Extremely Important**	
a.	Pesticide cost	341		347		353		359	
b.	Agr. Specialist advice	342		348		354		360	
c.	Pesticide dealer advice	343		349		355		361	
d.	Neighbor's advice	344		350		356		362	
e.	Safety	345		351		357		363	
f.	Others (specify)	346		352		358		364	

28. Did you borrow to finance your crop production?
____Yes ____ No (If no, go to question 32) 365 ______

29. What proportion of your borrowing came from each of the following sources?
(Check all that Apply)
____1) Agrarian/Commercial bank
____2) Other banks
____3) Friends, relatives, neighbors
____4) Money lenders
____5) Traders
____6) Others (specify)____________________

366	
367	
368	
369	
370	
371	

30. How much was your total borrowing for crop production last season?
372 ______ lek

31. How much lek borrowed in cash were spent on pesticides?
373 ______ lek

32. <u>If No,</u> What are the constraints for getting credit from the banks?
(Check all that apply)
____1) There are many bureaucratic procedures to follow
____2) Bank is far away from the commune or village
____3) Interest rates are very high
____4) Bank personnel is corrupted (have to pay bribes)
____5) Banks don't have money
____6) Don't have collateral
____7) Haven't tried to get credit

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32a. If you have access to credit, in which of the following agricultural sectors would you invest?
____1) Olive
____2) Citrus
____3) Vineyards
____4) Other Fruit Trees
____5) Other sectors (specify)_______________

381	
382	
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IV. Perceptions of the Effect of Pesticides on Human Health and Environment

33. Using pesticides to control pests can harm water quality:
____1) Agree
____2) Disagree
____3) Don't know

41	

34. Do you think water quality in your area has been negatively affected by pesticide use ?
____1) Yes
____2) No
____3) Don't know

42	

35. Do you attribute any health problems that you or any of your family may have experienced to pesticides?
____1) Yes
____2) No
____3) Don't know

43	

V. Knowledge of Olive Pests and their Natural Enemies

A. Knowledge of Olive Pests

36. What are the olive pests that you know?
(Check all that Apply)
____1) Olive fly (Miza e Ullirit)
____2) Black scale (Breshkeza)
____3) Bloza
____4) Olive Moth (Tenja)
____5) Leaf spot (Syri i Palloit)
____6) Olive knot (Tuberkulozi)
____7) Others (specify)__________________________

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37. How do they damage the olive tree and fruits?

Pests	Damages the tree and leaves		Damages Olive fruit	
1) Olive fly	58		515	
2) Black scale	59		516	
3) Bloza	510		517	
4) Olive moth	511		518	
5) Leaf spot	512		519	
6) Olive Knot	513		520	
7) Others (specify)	514		521	

38. Which of these pests do you think causes the most severe damage to the olive tree?
(Check all that Apply)
____1) Olive fly
____2) Black scale
____3) Bloze
____4) Olive moth
____5) Leaf spot
____6) Olive knot
____7) Others (specify)__________________________

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39. Do you think it is necessary to use chemicals to control these olive pests?
____1) Yes
____2) No
____3) Don't know

529	

B. Knowledge of Natural Enemies of Olive Pests

40. Are there insects/animals that do not cause damage to your olive trees?
____1) Yes
____2) No (Go to Q.45)
____3) Don't know (Go to Q.45)

530	

41. If Yes, what are they? Name as many as you can.
____1) Red Ants
____2) Birds
____3) Spider
____4) Other (specify)___________________

531	
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534	

41a. What do these insects/animals do in your trees?
____1) Kill/eat pests
____2) Spins web/lives in olive trees
____3) Flies from tree to tree
____4) Feeds on the olive fruit

535	
536	
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538	

42. What do you think happens to these insects/animals when chemicals are applied on your olive trees?
____1) All are killed/die
____2) Some killed/die
____3) Decrease in number
____4) Nothing happens
____5) Don't know

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43. Do you think that applying pesticides to the olive trees will make the yield go up?
____1) Agree
____2) Disagree
____3) No opinion

544	

44. Do you think that killing the natural enemies of pests in your olive orchard
by applying chemicals can stimulate pest infestation?
____1) Agree
____2) Disagree
____3) No opinion

545	

VI. Olive Pest Management Practices

45. What olive pests did you have last season?
(Check all that apply)
____1) Olive fly
____2) Black scale
____3) Bloze
____4) Olive moth
____5) Leaf spot
____6) Olive knot
____7) Others (specify)__________________________

61	
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46. How did you control these olive pests last season?
(Check all that apply)
____1) Pesticide application
____2) Mechanical Method
____3) Pruning
____4) Tilling of area under the tree
____5) No control
____6) Others (Specify)__________________________

68	
69	
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612	
613	

47. What olive pest caused the biggest damage to your olive trees last season?
(Check from the following the 1st and 2nd most important pest)
____1) Olive fly
____2) Black scale
____3) Bloze
____4) Olive moth
____5) Leaf spot
____6) Olive knot
____7) Others (specify)__________________________
a) First most important olive pest
b) Second most important olive pest

614	
615	

48. What did you do to control these olive pests last season?
For your most important pest :
(Check all that apply)
____1) Pesticide application
____2) Mechanical Method
____3) Pruning
____4) Tilling of area under the tree
____5) No control
____6) Others (Specify)_________________________

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For your 2nd most important pest:
(Check all that apply)
____1) Pesticide application
____2) Mechanical Method
____3) Pruning
____4) Tilling of area under the tree
____5) No control
____6) Others (Specify)_________________________

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49. Did you apply pesticides in your olive trees last season?
____1) Yes ____2) No (GO to Q.57)

628	

50-52. Please tell me at what stage(s) of the olive production did you apply pesticides last season. What chemicals did you apply at these stages? For which olive pests?

Time of application (Q.50)	**Pesticides applied (Q.51)**		**Target olive pests (Q.52)**	
a. Before flowering	629		634	
b. Flowering	630		635	
c. Fruiting	631		636	
d. Before harvesting	632		637	
e. Other (specify)	633		638	

53. Can you tell me the reason why you applied pesticides at these times?
____1) To prevent pest infestation
____2) To control pest infestation
____3) Other (specify)_________________________

639	

54. How effective were these chemicals?
____1) Effective
____2) Not effective
____3) Don't know

640	

55. How much did you spend on these chemicals last season?

____1) I paid myself
____2) Paid by Department of Agriculture

641		lek
642		

56. Did you apply pesticides yourself?
____1)Yes ____ 2)No

643	

56a. <u>If No</u>, how much did you pay for hired labor or spraying service?

644		Lek

57. Can you tell me the reasons why you haven't applied pesticides in your olive trees?
(Check all that apply)
____1) Price of pesticides is high
____2) I'm not sure about the quality of pesticides
____3) Pesticides are not available locally
____4) Don't know how to apply pesticides
____5) Don't have spraying equipment
____6) Have no idea about pest control practices
____7) Olive is not that important as a farm activity
____8) Other farmers (neighbors) don't apply pesticides
____9) Other (specify) ___________________________

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58. Do you have a sprayer?
____1)Yes ____ 2)No (If No, go to Q. 58c)

654	

58a. <u>If Yes</u>, what kind of sprayer do you have?
____1) Knapsack (back pump)
____2) Hand sprayer
____3) Tractor pump
____4) Other (specify)_____________________________

655	
656	
657	
658	

58b. How often do you calibrate your pesticide application equipment?
(Check all that apply)
____1) At the time of equipment purchase
____2) Before each application
____3) Once a season
____4) Every two to three years
____5) Never

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58c. If No, where do you get a sprayer when needed?
____1) Borrow
____2) Rent
____3) Hired labor provides sprayer
____4) I don't use a sprayer
____5) Other (specify)_________________________

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59. Are there individuals or associations that offer spraying services in your area?
____1)Yes ____2)No

669	

VII. Information and Innovations

60. Who recommends or from where do you get olive pest control advice?
(Check all that apply)
____1) Magazine, radio or TV advertisement
____2) Extension specialist
____3) Research specialist
____4) Neighbor or another farmer/grower
____5) Relatives
____6) Pesticide sale agents
____7) Private consultant
____8) Your own experience and/or past success with product
____9) Other (specify)________________________________

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60a. If more than one response in Q.60, which of these sources of olive pest control advice is most credible to you?
(Check all that apply)
____1) Magazine, radio or TV advertisement
____2) Extension specialist
____3) Research specialist
____4) Neighbor or another farmer/grower
____5) Relatives
____6) Pesticide sale agents
____7) Private consultant
____8) Your own experience and/or past success with product
____9) Other (specify)________________________________

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60b. Whom would you ask first for advice if an insect pest you did not recognize was seriously damaging your olive trees?
____1) Magazine, radio or TV advertisement
____2) Extension specialist
____3) Research specialist
____4) Neighbor or another farmer/grower
____5) Relatives
____6) Pesticide sale agents
____7) Private consultant
____8) Your own experience and/or past success with product
____9) Other (specify)________________________________

719	

60c. Why? ____
____

61. Do you know about any farmer training courses that have been organized in your area?
____1)Yes ____2) No
720 ☐

61a. If Yes, have you participated in such courses in the last five years?
____1)Yes ____2) No
721 ☐

61b. Are you interested in attending such courses?
____1)Yes ____2) No
722 ☐

62. Have you attended any training on olive pest control?
____1)Yes ____2) No
723 ☐

62a. If Yes, what was that training about?________________________

63. When was the last time you had an unpaid (public extension service or department of agriculture) agricultural technician on the farm?
____1) Twice or more in the last year
____2) Less than twice in the last year
____3) Never
____4) Can't remember
724 ☐

64. Has an agricultural technician, who discussed non-pesticide means of controlling crop pests, ever visited you?
____1)Yes ____2) No
725 ☐

65. For your farming activities, do you rate agricultural information and technical assistance as:
____1) Very necessary
____2) Necessary
____3) Unnecessary
____4) Don't know
726 ☐

66. Do you think you have:
____1) Adequate access to agric. information and tech. assistance
____2) Inadequate access to agric. information and tech. assistance
727 ☐

66a. Do you think the state support for farmers and agriculture should be:

____1) More than before '90-s
____2) Same as before '90-s
____3) Less than before '90-s
____4) No Support at all
____5) Don't know
728 ☐

67. Can you think of anything new you have successfully introduced into your olive production system in the last five years?
____1)Yes ____2) No
729 ☐

67a. If Yes, have you applied any of the following practices for pest control in your olive trees?
(Check all that Apply)
____1) Light pruning
____2) Heavy pruning
____3) Use of pest resistant olive cultivars
____4) Application of some sort of trapping methods
____5) Tilling of area under the olive tree
____6) Irrigation
____7) Use of sheep or hens to eat olive fly
____8) Other (specify)________________________

730	
731	
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733	
734	
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736	
737	

67b. Where did the ideas come from?
____1) Neighbor/other farmer
____2) Self
____3) Extension specialist
____4) Research center
____5) University
____6) Written material/publications
____7) Agricultural radio/TV program
____8) Other (specify)________________________

738	
739	
740	
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742	
743	
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745	

67c. If No, why not?
____1) Haven't really thought about it
____2) Can't afford financially
____3) No access to credit
____4) Would not be economical
____5) Don't know how to get help/advice
____6) Other comments (specify)_______________

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747	
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750	
751	

68. Are you considering any such major restructuring?
____1)Yes ____2)No

752	

Details, comments, impediments etc……………………………………

VIII. Socio-Demographic Profile

69. What is your age?

81		Years

69a. Gender
____1) Male ____2) Female

82	

70. How long have you been working in olive production sector?
____1) Less than 5 years
____2) 5-10 years
____3) 10-20 years
____4) More than 20 years

83	

71. What is your tenure status?
(Check all that apply)
____1) Owner-operator
____2) Tenant
____3) Sharecropper
____4) Hired laborer
____5) Others (specify)___________________

84	
85	
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88	

72. What is the size of your family?

89	

73. How many working persons are there in your family?
Of which:
1) Work on the farm?
2) Work off the farm?

810	
811	
812	

74. For each family member of age 15 or older who work on the farm, please give the highest grade/year completed ?

Family Members	**No school**	**Elementary**	**Middle**	**High**	**University**
Husband					
Wife					
1					
2					
3					
4					
5					

No school	813	
Elementary	814	
Middle	815	
High	816	
University	817	

75. What farmer organizations are you a member of?
____1) ________________________________
____2) ________________________________
____3) ________________________________

818	
819	
820	

76. Could you please rank major sources of income for your family?
____1) Crops
____2) Olive
____3) Other Fruit Trees
____4) Livestock
____5) Remittances
____6) Non-farm labor

821	
822	
823	
824	
825	
826	

PM CRSP / Albania Project

Follow-up Survey

Interview Questionnaire

Household no. ________________ **Date of Interview** ________________
Respondent ________________ **Interviewer** ________________
Village ________________ **Commune** ________________

1. What is your current farm size?	101		ha
2. How many olive trees do you have on your farm?	102		trees
3. In how many places are your olive trees located?	103		
4. How far is your farm from research station of the FTRI?	104		km

5. Did you use pesticides in fruit trees (other than olives) last year? (Check all that apply)

a. Other fruit Trees	___1) Yes	___2) No	105	
b. Citrus	___1) Yes	___2) No	106	
c. Vineyards	___1) Yes	___2) No	107	

6. Did you apply pesticides in your olive trees last season?

____1) Yes ____2) No | 108 | |

7. What other methods did you apply for control these olive pests last season?
(Check all that apply)

1)Yes____	2)No____	Light and heavy pruning	109	
1)Yes____	2)No____	Use of pest resistant olive cultivars	110	
1)Yes____	2)No____	Application of some sort of trapping methods	111	
1)Yes____	2)No____	Tilling of area under the olive tree	112	
1)Yes____	2)No____	Use of sheep or hens to eat olive fly	113	
1)Yes____	2)No____	No control	114	

8. Do you have a sprayer?
____1)Yes ____ 2)No | 115 | |

9. Who recommends or from where do you get olive pest control advice?
(Check all that apply)

1)Yes____	2)No____	Radio and/or TV advertisement	201	
1)Yes____	2)No____	Magazines and newspapers	202	
1)Yes____	2)No____	Extension specialist	203	
1)Yes____	2)No____	Pesticide dealers	204	
1)Yes____	2)No____	Neighbor or another farmer/grower	205	
1)Yes____	2)No____	Your own experience or past success with product	206	

10. How many times did you have an unpaid (public extension service or department of agriculture) agricultural technician on the farm (check one)?

____1) Twice or more in the last year
____2) Less than twice in the last year
____3) Never
____4) Can’t remember

207	

11. I would like to ask for your opinions on pest control strategies. These questions will ask you whether you strongly agree, agree, have no opinion, disagree, or strongly disagree with them. There are no right or wrong answers; these are only your opinions:

11a. The use of pesticides to control pests causes harmful effects to human health and environment. Do you:

301	

Strongly disagree		Disagree		No opinion		Agree		Strongly agree	
1		2		3		4		5	

11b. Farmers can expect higher average yields by using scouts rather than by spraying by calendar. Do you:

304	

Strongly disagree		Disagree		No opinion		Agree		Strongly agree	
1		2		3		4		5	

11c. People disagree about the differences in yield produced by integrated pest management (IPM) vs. conventional pest management practices. Some say IPM is less risky than conventional methods. Others say the opposite. Do you think IPM reduces the chances of having extremely low-yielding years?

305	

Strongly disagree		Disagree		No opinion		Agree		Strongly agree	
1		2		3		4		5	

12. As you know pest management on olives has been totally disrupted with the collapse of the centralized economy. Since 1998, the IPM CRSP, a collaborating research program composed of American and Albanian scientists has been doing research in Vlora area to develop improved olive IPM tactics suitable for this region that will: (i) reduce crop losses, (ii) increase farmer income, (iii) minimize pesticide use by encouraging only appropriate and prudent use according to IPM principles, (iv) minimize pesticide residues in olive products, and (v) improve farmers’ ability to monitor pests. These olive IPM tactics are expected to be available to farmers within a short period of time. Once they are available, would you be willing to apply these improved IPM practices for controlling olive fly and black scale on your olive trees?

____1) Yes ____2) No

401	

13. If YES, what percentage of your olive trees would you be willing to treat with these improved IPM tactics? (check one)

402	

25%		50%		75%		100%	

14. What is your age?

501		Years

15. How long have you been working in olive production sector?

502		Years

16. How many people live in your household?

503	

17. Do you have children (less than 15 years old) in your household?

____1) Yes ____2) No

504	

18. What is your level of education? (Check one)

505	

No school		Elementary		Middle		High		University	
0		4		8		12		16	

19. How many of your family members of age 15 or older, who work on the farm, have at least high school education?

506	

20. Do you consider olives (other than remittances) as major sources of income for your family?

____1) Yes ____2) No

601	

21. For your olives last year, please provide the following information?

Products	Production (kilo)		Sold (kilo)		Price (lek/kilo)		Sale Income (lek)	
Olive	602		603		604		605	
Olive oil	606		607		608		609	

22. What was your olive yield last season?

610		kilo/olive tree

23. How many crops did you cultivated in the arable land you own?

611	

Appendix D

Baseline Survey Results (Tables D5.1-D5.30)

Table 5.1 Socio-demographic Profiles of Farmers Interviewed. Vlora, Albania, 1999.

VARIABLES	**No. of Farmers responding in each Village**					**Total Farmers**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Gender						
Male	33 (97.0)	44 (97.7)	31 (86.2)	51 (94.4)	31 (100)	190 (95)
Female	1 (3.0)	1 (2.3)	5 (13.8)	3 (5.6)	0 (0.0)	10 (5)
Age Class						
Below 31	1 (3.0)	1 (2.2)	3 (8.3)	5 (9.3)	0 (0.0)	10 (5.0)
31 to 40	7 (20.6)	7 (15.6)	9 (25.0)	19 (35.2)	5 (16.1)	47 (23.5)
41 to 50	9 (26.5)	16 (35.6)	8 (22.7)	11 (20.4)	13 (42.0)	57 (28.5)
51 to 60	9 (26.5)	16 (35.6)	7 (19.5)	10 (18.5)	7 (22.6)	49 (24.5)
Above 60	8 (23.4)	5 (11)	9 (25.0)	9 (16.6)	6 (19.3)	37 (18.5)
Mean	51.23	49.48	49.55	46.61	51.19	49.3
SDEV	12.53	9.8	14.25	13.62	10.04	12.28
Tenure Status						
Owner-operator	34 (100)	45 (100)	36 (100)	54 (100)	31 (100)	200 (100)
Tenant	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Sharecropper	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Hired laborer	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Education Level						
No Schooling (0 yrs.)	1 (1.2)	3 (2.4)	1 (1.1)	2 (1.3)	1 (1.3)	8 (1.5)
Elementary (0-4 yrs.)	4 (4.9)	15 (12.0)	7 (7.7)	13 (8.5)	7 (9.0)	46 (8.7)
Middle (5-8 yrs.)	34 (41.5)	67 (53.6)	57 (62.6)	99 (64.7)	48 (61.4)	305 (57.7)
High (9-12 yrs.)	40 (48.8)	37 (29.6)	24 (26.4)	39 (25.5)	21 (27.0)	161 (30.4)
College (more than 12 yr)	3 (3.6)	3 (3.6)	2 (2.2)	0 (0.0)	1 (1.3)	9 (1.7)
Mean	9.95	8.74	8.9	8.6	8.8	9
SDEV	2.83	3.03	2.6	2.43	2.6	2.72

Values in parenthesis ( ) represent percentage of farmers in the village having such characteristics.

Table 5.2. Distribution of Family Size and Labor Usage in the Family. Vlora, Albania, 1999.

VARIABLES	**No. of farmers responding in each village**					**Total Farmers**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Family Size						
2 or less	0 (0.0)	2 (4.4)	0 (0.0)	1 (1.9)	0 (0.0)	3 (1.5)
3 to 4	11 (32.3)	10 (22.2)	10 (27.8)	15 (27.8)	8 (25.8)	54 (27)
5 to 6	19 (55.9)	22 (48.9)	17 (47.2)	16 (29.6)	13 (42)	87 (43.5)
7 to 8	4 (11.8)	9 (20)	5 (13.8)	12 (22.2)	8 (25.8)	38 (19)
9 to 10	0 (0.0)	0 (0.0)	2 (5.6)	6 11.1)	2 (6.4)	10 (5.0)
Above 10	0 (0.0)	2 (4.5)	2 (5.6)	4 (7.4)	0 (0.0)	8 (4.0)
MEAN	5	5.6	5.7	6.4	5.7	5.7
STDEV	1.3	2.1	2	2.9	1.7	2.2
Median	5	5	5	6	5	5
No. of Labor persons within the family:						
Total	94	139	117	196	105	651
of which:						
Work on the farm	76 (80.1)	112 (80)	76 (65)	145 (74)	78 (74)	487 (75)
Work off the farm	18 (19.9)	27 (20)	41 (35)	51 (26)	27 (26)	164 (25)
Experience working with olives						
5 yrs or less	2 (5.9)	0 (0.0)	4 (11.1)	2 (3.7)	1 (3.2)	9 (4.5)
5 to 10 years	3 (8.8)	5 (11.1)	8 (22.2)	3 (5.6)	6 (19.4)	25 (12.5)
10 to 20 years	7 (20.6)	10 (22.2)	7 (19.5)	19 (35.2)	4 (12.9)	47 (23.5)
More than 20 yrs	22 (64.7)	30 (66.7)	17 (47.2)	30 (55.5)	20 (64.5)	119 (59.5)

Values in parenthesis ( ) represent column percentages

Table 5.3 Distribution of Farmers by Farm Size. Vlora, Albania, 1999.

Farm Size (ha)		**No. of farmers responding in each village**					**Total**
		Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers**
	.5 or less	2 (5.9)	2 (4.4)	10 (27.8)	6 (11.1)	3 (9.8)	23 (11.5)
Between	.5 and 1	8 (23.5)	9 (20)	4 (11.1)	21 (38.9)	9 (29)	51 (25.5)
"	1 and 1.5	11 (32.3)	13 (28.9)	8 (22.2)	17 (31.5)	12 (38.7)	61 (30.5)
"	1.5 and 2	8 (23.5)	8 (17.8)	9 (25)	2 (3.7)	5 (16.1)	32 (16)
"	2 and 2.5	1 (3)	8 (17.8)	3 (8.3)	2 (3.7)	0 (0.0)	14 (7.0)
"	2.5 and 3	3 (8.8)	4 (8.9)	1 (2.8)	2 (3.7)	1 (3.2)	11 (5.5)
More than 3		1 (3)	1 (2.2)	1(2.8)	4 (7.4)	1 (3.2)	8 (4.0)
MEAN		1.48	1.66	1.33	1.84	1.51	1.59
SDEV		0.76	0.74	0.85	1.7	1.34	1.61
MEDIAN		1.28	1.5	1.25	1.05	1.5	1.23

Values in parenthesis ( ) represent column percentages

Table 5.4 Distribution of Farmers by Number of Olive Trees. Vlora, Albania, 1999.

No. of Olive Trees		**No. of farmers responding in each village1**					**Total**
		Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers1**
	30 or less	1 (2.9)	21 (46.7)	10 (27.8)	10 (18.6)	11 (35.5)	53 (26.5)
Between	30 and 60	11 (32.4)	18 (40)	9 (25)	32 (59.3)	10 (32.2)	80 (40)
"	60 and 90	7 (20.6)	5 (11.1)	5 (13.8)	10 (18.5)	8 (25.8)	35 (17.5)
"	90 and 120	11 (32.3)	0 (0.0)	8 (22.2)	1 (1.8)	2 (6.5)	22 (11)
"	120 and 150	2 (5.9)	1 (2.2)	2 (5.6)	0 (0.0)	0 (0.0)	5 (2.5)
More than 150		2 (5.9)	0 (0.0)	2 (5.6)	1 (1.8)	0 (0.0)	5 (2.5)
MEAN		85	38.5	68.5	49	50.5	56.5
SDEV		36.2	21.4	51.1	29.3	25.4	36.9
MEDIAN		78	35	57	43	40	45
No. of Olive Trees2		2886 (25.5)	1733 (15.3)	2465 (21.8)	2652 (23.5)	1566 (13.9)	11302 (100)
of which:							
Table Varieties		70 (2.4)	40 (2.3)	67 (2.7)	40 (1.5)	30 (1.9)	247 (2.2)
Oil Varieties		1097 (38)	653 (37.7)	508 (20.6)	990 (37.3)	413 (26.4)	3661 (32.4)
Mixed Varieties		1719 (59.6)	1040 (60)	1890 (76.7)	1622 (61.2)	1123 (71.7)	7394 (65.4)

1 Values in parenthesis ( ) represent column percentages
2 Values in parenthesis ( ) represent row percentages

Table 5.5 Number of Farmers Planting Olive Seedlings and Sources of Seedlings. Vlora, Albania, 1999.

VARIABLES	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Planted olive seedlings (in last five years) **:**						
Yes	4 (11.8)	20 (44.4)	10 (27.8)	5 (9.3)	11 (35.5)	50 (25)
No	30 (88.2)	25 (55.6)	26 (72.2)	49 (90.7)	20 (64.5)	150 (75)
Number of seedlings planted:	165 (10)	670 (44)	323 (21)	42 (3.0)	326 (21)	1526 (100)
Primary source of seedlings: *						
Private sector grower	1 (25)	4 (20)	3 (30)	3 (60)	5 (45.5)	16 (32)
Department of Agriculture	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Research Institute	2 (50)	14 (70)	4 (40)	2 (40)	5 (45.5)	27 (54)
Self	1 (25)	0 (0.0)	1 (10)	0 (0.0)	1 (9.0)	3 (6.0)
Friend/Neighbor	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Traders	0 (0.0)	2 (10)	2 (20)	0 (0.0)	0 (0.0)	4 (8.0)
When planted:						
December	1	8	5	0	1	15 (29.4)
January	2	11	5	4	4	26 (51)
February	2	1	0	1	6	10 (19.6)
Others						
Olive varieties grown on the farm						
Kalinjot	33 (49.3)	43 (75.4)	36 (53)	51 (64.6)	30 (76.9)	193 (62.2)
Pula Zeqin	24 (35.8)	7 (12.3)	25 (36.7)	23 (29.1)	5 (12.8)	84 (27.1)
Frantoju	10 (14.9)	3 (5.3)	6 (8.8)	3 (3.8)	4 (10.3)	26 (8.4)
Wild	0 (0.0)	4 (7.0)	1 (1.5)	2 (2.5)	0 (0.0)	7 (2.3)

Values in parenthesis ( ) represent column percentages
*\Multiple responses

Table 5.6 Distribution of Farmers by Number, Production, and Sales of Fruit Trees. Vlora, Albania, 1999.

VARIABLES	Villages					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Fruit Trees:						
No. of Farmers	13 (38)	14 (31)	15 (42)	10 (19)	11 (35)	63 (31.5)
Production (kv) *\\	24.3(22.8)	24.7(23.2)	26.9(25.3)	7.8 (7.3)	22.7(21.4)	106.4 (100)
Consumption (kv)	19.2 (79)	20.7 (84)	21.9(81.5)	7.8(100)	22.7(100)	92.3(86.8)
Sales (%)	5.1 (21)	4 (16)	5 (18.5)	0 (0.0)	0 (0.0)	14.1(13.2)
Citrus						
No. of Farmers	2 (6.0)	16 (36)	6 (17)	4 (7.0)	4 (13)	32 (16)
Production (kv) *\\	0.75(1.4)	40.7(76.3)	2.6(4.9)	2.1 (4.0)	7.2(13.4)	53.35(100)
Consumption (kv)	0.75(100)	21.7(53.3)	2.6(100)	2.1(100)	7.2(100)	34.35(64.4)
Sales (%)	0 (0.0)	19(46.7)	0 (0.0)	0 (0.0)	0 (0.0)	19(35.6)
Vineyards						
No. of Farmers	21 (62)	15 (33)	8 (22)	37 (69)	14 (45)	95 (47.5)
Production (kv) *\\	306(61)	22.6(4.5)	51 (10.2)	96.1(19)	26.5(5.3)	502.2(100)
Consumption (kv)	121(39.5)	2.5 (11)	36(70.6)	23.9(24.9)	11.8(44.5)	195.2(39)
Sales (%)	185(60.5)	20.1 (89)	15(29.4)	72.2(75.1)	14.7(55.5)	307(61)

Values in parenthesis ( ) represent column percentages.
*\ Values in parenthesis ( ) represent row percentages.

Table 5.7 Distribution of Olive Yields Obtained by Farmers Last Season. Vlora, Albania, 1999.

Yields (kg/tree)	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
10 or less	1 (3.0)	4 (8.9)	7 (19.4)	5 (9.3)	1 (3.2)	18 (9.0)
Between 10 and 20	11 (32.2)	12 (26.7)	11 (30.6)	4 (7.4)	9 (29)	47 (23.5)
" 20 and 30	9 (26.5)	15 (33.3)	4 (11.1)	18 (33.3)	5 (16.1)	51 (25.5)
" 30 and 40	4 (11.8)	10 (22.2)	8 (22.2)	9 (16.7)	4 (12.9)	35 (17.5)
" 40 and 50	6 (17.6)	2 (4.5)	2 (5.6)	7 (13)	7 (22.6)	24 (12)
" 50 and 60	3 (8.8)	1 (2.2)	1 (2.8)	5 (9.3)	4 (12.9)	14 (7.0)
" 60 and 70	0 (0.0)	0 (0.0)	2 (5.5)	3 (5.5)	0 (0.0)	5 (2.5)
More than 70	0 (0.0)	1 (2.2)	1 (2.8)	3 (5.5)	1 (3.3)	6 (3.0)
MEAN	30.1	28.2	28	35.8	34.7	31.1
SDEV	14.8	13.9	20.9	18.8	18.5	18.3
MEDIAN	29.3	27	21.5	30.5	35	30

Values in parenthesis ( ) represent column percentages

Table 5.8 Farmers' Major Sources of Income. Vlora, Albania, 1999.

Villages	Most Important Source		2nd Most Important Source		3rd Most Important Source		4th Most Important Source	
	No. of farmers (%)		No. of farmers (%)		No. of farmers (%)		No. of farmers (%)	
Crops	16	8	18	9	11	5.5	10	5
Olive	91	45.5	77	38.5	15	7.5	2	1
Other fruit trees	17	8.5	39	19.5	26	13	2	1
Livestock	7	3.5	22	11	20	10	11	5.5
Remittances	41	20.5	9	4.5	5	2.5	2	1
Non-farm labor	28	14	17	8.5	7	3.5	2	1
	200	100	182	91	84	42	29	14.5

Distribution of Farmers Reporting Olives as the Most Important Source of Income. Vlora, Albania, 1999.

Villages	No. of Farmers	Percentage
Bestrove	18	53
Cerkovine	19	42.2
Kanine	18	50
Panaja	19	35.2
Tre Vellazen	17	54.8
Total	91	45.5

Values in parenthesis ( ) represent row percentages of total farmers.

Table 5.9 Statistics on Production, Consumption, and Sales of Olives and Olive Oil, Vlora, Albania, 1999.

VARIABLES	**Villages**					**Total**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers**
Olive:						
No. of Farmers	34	45	36	54	31	200
Production (kv) *\	783.9(25.3)	407(13.2)	540.3(17.5)	847.2(27.4)	514(16.6)	3092.4 (100)
Consumption (kv)	73.2 (9.3)	48.7 (12)	41 (7.6)	83.4(9.8)	34.5(6.7)	280.8(9.1)
Processed (kv)	707.7(90.3)	355.3(92.4)	499.3(92.4)	760.3(89.7)	479.5(93.3)	2802.1(90.6)
Sales (kv)	3 (0.4)	3 (0.7)	0 (0.0)	3.5 (0.5)	0 (0.0)	9.5 (0.3)
Average Price (lek/kilo)	167.5	186.7	0	183	0	178
Olive Oil:						
No. of Farmers	34	43	34	53	31	195
Production (kv) *\	159.9(24.5)	85 (13)	113(17.3)	180.3(27.6)	114.8(17.6)	653(100)
Consumption (kv)	51.9(32.5)	45.7(53.8)	47(41.6)	84.7(47)	43.2(37.6)	272.5(41.7)
Sales* (kv)	108(67.5)	39.3(46.2)	66(58.4)	95.6(53)	71.6(62.4)	380.5(58.3)
Average Price (lek/kilo)	304	316	294	300	301	302.5

Values in parenthesis ( ) represent column percentages
*\ Values in parenthesis ( ) represent row percentages

Table 5.10 Distribution of Olive Income Obtained by Farmers Last Season. Vlora, Albania, 1999.

	No. of farmers responding in each village					**Total**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers**
Income from pickled olive sale (lek)						
10,000 or less	1 (33.3)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	2 (22.2)
Between 10,000 and 40,000	2 (66.7)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	3 (33.3)
" 40,000 and 80,000	0 (0.0)	1 (33.3)	0 (0.0)	1 (33.3)	0 (0.0)	2 (22.2)
" 80,000 and 120,000	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	1 (11.1)
More than 120,000	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (11.2)
MEAN	18,333	92,666	0	69,666	0	60,222
SDEV	10,692	81,739	0	56,216	0	59,792
MEDIAN	160,000	80,000	0	80,000	0	30,000
Income from olive oil sale (lek)						
20,000 or less	1 (4.4)	3 (15)	1 (5.2)	2 (6.1)	3 (15)	10 (8.7)
Between 20,000 and 60,000	4 (17.4)	13 (65)	7 (36.8)	15 (45.5)	6 (30)	45 (39.1)
" 60,000 and 100,000	4 (17.4)	1 (5.0)	3 (15.8)	5 (15.2)	3 (15)	16 (13.9)
" 100,000 and 140,000	6 (26)	1 (5.0)	3 (15.8)	7 (21.2)	2 (10)	19 (16.5)
" 140,000 and 180,000	2 (8.7)	1 (5.0)	3 (15.8)	1 (3.0)	3 (15)	10 (8.7)
" 180,000 and 220,000	2 (8.7)	0 (0.0)	0 (0.0)	2 (6.0)	2 (10)	6 (5.2)
" 220,000 and 260,000	1 (4.4)	0 (0.0)	1 (5.3)	1 (3.0)	0 (0.0)	3 (2.7)
More than 260,000	3 (13)	1 (5.0)	1 (5.3)	0 (0.0)	1 (5.0)	6 (5.2)
MEAN	140,978	76,875	98,842	81,787	100,340	98,815
SDEV	95,663	113,901	71,252	55,968	80,234	84,909
MEDIAN	120,000	46,500	75,000	60,000	82,500	72,500

Values in parenthesis ( ) represent column percentages

Table 5.11 Processing of Olive for Oil. Vlora, Albania, 1999.

VARIABLES	Villages					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Location of Processing:						
Home	0 (0.0)	2 (4.4)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.0)
Factory	34 (100)	43 (95.6)	34 (100)	53 (100)	23 (100)	187 (99)
Number of processing factories in the village: *	1 (12.5)	1 (12.5)	2 (25)	3 (37.5)	1 (12.5)	8 (100)
Is the no. and capacity of such factories enough:						
Yes	6 (18.2)	21 (46.7)	3 (8.3)	45 (91.8)	5 (20)	80 (42.6)
No	27 (81.2)	24 (53.3)	33 (91.7)	4 (8.2)	20 (80)	108 (57.4)
Distance of factories from the farm house (km):	1.41	1.95	6.9	0.7	2.2	2.9
Amount spent for transport:						
Olive groves - House	65.45	100	0	100	191	87
House - Factory	106.4	209	282	92	185	162
Amount spent for processing:						
MEAN	800	800	800	782	769	788
SDEV	0	0	162	38.5	47	78

Values in parenthesis ( ) represent column percentages.
*\ Values in parenthesis ( ) represent row percentages.

Table 5.12 Commercial Outlets and Constraints of Marketing Olive Products Vlora, Albania, 1999.

	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Commercial Outlets						
Local Trader	4 (11.8)	6 (13.3)	3 (8.3)	10 (18.5)	8 (25.8)	31 (15.5)
Local Market	14 (41.2)	19 (42.2)	17 (47.2)	18 (33.3)	9 (29)	77 (38.5)
Non-local Market	7 (20.6)	5 (11.1)	1 (2.8)	11 (20.4)	5 (16.1)	29 (14.5)
Trade Association	1 (2.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)
Olive Processors	1 (2.9)	0 (0.0)	2 (5.6)	0 (0.0)	0 (0.0)	3 (1.5)
No sale	7 (20.6)	15 (33.3)	13 (36.1)	15 (27.8)	9 (29)	59 (29.5)
Marketing Constraints						
Have nothing to sell	8 (8.4)	18 (22.5)	11 (10.4)	11 (6.2)	6 (6.1)[1]	54 (27)[2]
Prices are low	16 (16.9)	14 (17.5)	14 (13.2)	26 (14.6)	14 (14.3)	84 (42)
Markets are far away	15 (15.8)	11 (13.8)	14 (13.2)	18 (10.1)	17 (17.4)	75 (37.5)
Don't have vehicle for transportation	11 (11.6)	5 (6.2)	13 (12.3)	21 (11.8)	16 (16.3)	66 (33)
Price of transport is unaffordable	7 (7.4)	4 (5.0)	12 (11.3)	20 (11.3)	11 (11.2)	54 (27)
Don't know how to do packing and advertising	12 (12.6)	3 (3.8)	12 (11.3)	21 (11.8)	8 (8.2)	56 (28)
There are no local collection points	16 (16.8)	16 (20)	17 (16)	32 (18)	15 (15.3)	96 (48)
There are no markets	10 (10.5)	8 (10)	11 (10.4)	27 (15.1)	9 (9.2)	65 (32.5)
Don't have any problem	0 (0.0)	1 (1.2)	2 (1.9)	2 (1.1)	2 (2.0)	7 (3.5)

Multiple responses since farmers may mention more than one constraint.
1) Values in parenthesis ( ) represent column percentages.
2) Values in parenthesis ( ) represent percentage of total farmers who reported each constraint.

Table 5.13 Perceived Constraints for Getting Credit. Vlora, Albania, 1999.

Constraints	**No. of farmers responding in each village**					**Total**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers**
There are many bureaucratic procedures	18 (52.9)	18 (40)	16 (44.4)	29 (53.7)	11 (35.5)	92 (46)
Banks are far away from commune/village	3 (8.8)	0 (0.0)	6 (16.7)	6 (11.1)	6 (19.4)	21 (10.5)
Interest rates are very high	13 (38.3)	14 (31.1)	14 (38.9)	15 (27.8)	12 (38.7)	68 (34)
Bank personnel is corrupted	6 (17.7)	5 (11.1)	8 (22.2)	23 (42.6)	8 (25.8)	50 (25)
Banks don't have money	6 (17.7)	9 (20)	6 (16.7)	10 (18.5)	13 (42)	44 (22)
Don't have collateral	4 (11.8)	2 (4.4)	4 (11.1)	15 (27.8)	6 (19.4)	31 (15.5)
Haven't tried to get credit	21 (61.8)	28 (62.2)	23 (63.9)	34 (63)	19 (61.3)	125 (62.5)
Farmers' plan to invest in fruit trees, should they have access to credit:						
Olive Tree	27 (79.4)	39 (86.7)	33 (91.7)	43 (79.6)	29 (79.6)	171 (85.5)
Citrus	3 (8.8)	1 (2.2)	9 (25)	8 (14.8)	2 (14.8)	23 (11.5)
Vineyards	26 (76.5)	33 (73.3)	17 (47.2)	50 (92.6)	22 (92.6)	148 (74)
Other Fruit Trees	4 (11.8)	2 (4.4)	0 (0.0)	5 (9.3)	2 (9.3)	13 (6.5)
Other sectors	5 (14.7)	7 (15.6)	2 (5.6)	3 (5.6)	1 (5.6)	18 (9.0)

Multiple responses since farmers may mention more than one constraint.
Values in parenthesis ( ) represent percentage of farmers in the village who considered each reason.

Table 5.14 Distribution of Olive Trees. Vlora, Albania, 1999.

VARIABLES	**No. of farmers responding in each village**					**Total**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	**Farmers**
Number of places where olive trees are located						
1	1 (2.9)	2 (4.5)	9 (25)	13 (24.1)	9 (29)	34 (17)
2	10 (29.4)	19 (42.2)	22 (61.1)	11 (20.4)	16 (51.6)	78 (39)
3	16 (47.1)	18 (40)	5 (13.9)	23 (42.6)	1 (3.2)	63 (31.5)
4	7 (20.6)	4 (8.9)	0 (0.0)	6 (11.1)	4 (13)	21 (10.5)
5	0 (0.0)	2 (4.4)	0 (0.0)	1 (1.8)	1 (3.2)	4 (2.0)
MEAN	2.85	2.7	1.89	2.46	2.1	2.4
SDEV	0.78	0.95	0.62	1.04	1.08	0.97
Olive trees were taken over by farmers in:						
1991	16 (47.1)	24 (53.3)	23 (63.9)	31 (57.4)	19 (61.3)	113 (56.5)
1992	5 (14.7)	20 (44.4)	13 (36.1)	20 (37)	7 (22.5)	65 (32.5)
1993	5 (14.7)	1 (2.3)	0 (0.0)	3 (5.6)	2 (6.5)	11 (10.5)
1994	8 (23.5)	0 (0.0)	0 (0.0)	0 (0.0)	3 (9.7)	11 (10.5)
1995	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Olive trees were distributed:						
According to the law	34 (100)	45 (100)	36 (100)	52 (96.2)	31 (100)	198 (99.0)
Acc. to origin. ownership	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.8)	0 (0.0)	2 (1.0)
Other ways	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Values in parenthesis ( ) represent column percentages

Table 5.15 Sources of Pest Control Advice in Olives and their Perceived Credibility. Vlora, Albania, 1999.

	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Sources						
Magazine, Radio or TV advertisement	9 (26.5)	10 (22.2)	11 (30.6)	13 (24.1)	7 (22.6)	50 (25)
Extension specialists	22 (64.7)	24 (53.3)	10 (27.8)	16 (29.6)	15 (48.4)	87 (43.5)
Research specialists	10 (29.4)	14 (31.1)	3 (8.3)	5 (9.3)	17 (54.8)	49 (24.5)
Neighbor or another farmer/grower	16 (47.1)	6 (13.3)	21 (58.3)	29 (53.7)	9 (29)	81 (40.5)
Relatives	9 (26.5)	8 (17.8)	11 (30.6)	25 (46.3)	7 (22.6)	60 (30)
Pesticide dealer	9 (26.5)	12 (26.7)	8 (22.2)	7 (13)	4 (12.9)	40 (20)
Private consultant	4 (11.8)	2 (4.4)	3 (8.3)	5 (9.3)	3 (9.7)	17 (8.5)
Self/own experience	20 (58.8)	19 (42.2)	18 (50)	45 (83.3)	19 (61.3)	121 (60.5)
Ranked as most imports source						
Magazine, Radio or TV advertisement	3 (8.8)	6 (13.3)	4 (11.1)	6 (11.1)	5 (16.1)	24 (12)
Extension specialists	22 (64.7)	24 (53.3)	9 (25)	16 (30)	15 (48.4)	86 (43)
Research specialists	12 (35.3)	15 (33.3)	7 (19.4)	5 (9.3)	13 (42)	52 (26)
Neighbor or another farmer/grower	6 (17.7)	3 (6.7)	11 (30.6)	18 (33.3)	6 (19.4)	44 (22)
Relatives	5 (14.7)	4 (8.9)	1 (2.8)	11 (20.4)	6 (19.4)	27 (13.5)
Pesticide dealer	3 (8.8)	3 (6.7)	7 (19.4)	1 (1.9)	2 (6.5)	16 (8.0)
Private consultant	3 (8.8)	2 (4.4)	4 (11.1)	3 (5.6)	2 (6.5)	14 (7.0)
Self/own experience	14 (41.2)	15 (33.3)	15 (41.7)	38 (70.4)	14 (45.2)	96 (48)
Reasons given for credibility	**Knowledgeable**	**Experienced**	**Univ. Education**	**Tells what to do**	**Accessible**	**No other Alternative**
Magazine, Radio or TV advertisem.	2 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Extension specialists	43 (66.2)	23 (49)	23 (69.7)	21 (61.8)	0 (0.0)	3 (21.4)
Research specialists	12 (18.5)	5 (10.6)	1 (3.0)	13 (38.2)	5 (71.4)	0 (0.0)
Neighbor or another farmer/grower	5 (7.7)	10 (21.3)	3 (9.1)	0 (0.0)	2 (28.6)	3 (21.4)
Relatives	0 (0.0)	1 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Pesticide dealer	1 (1.5)	1 (2.1)	2 (6.1)	0 (0.0)	0 (0.0)	4 (28.6)
Private consultant	1 (1.5)	2 (4.3)	2 (6.1)	0 (0.0)	0 (0.0)	1 (7.1)
Self/own experience	1 (1.5)	5 (10.6)	2 (6.0)	0 (0.0)	0 (0.0)	3 (21.5)

Multiple responses since farmers may mention more than one constraint.
Values in parenthesis ( ) represent percentage of farmers responding in each village.

Table 5.16 Contacts with Extension and Attendance in Olive Pest Control Training Courses by Farmers. Vlora, Albania, 1999.

Villages	Attended Training		Have not Attended Training		Interested in Training		Not interested in Training	
	No. of farmers	(%)	No. of farmers	(%)	No. of farmers	(%)	No. of farmers	(%)
Bestrove	0	0	34	100	29	85.3	5	14.7
Cerkovine	2	4.4	43	95.6	36	80	9	20
Kanine	1	2.8	35	97.2	30	83.3	6	16.7
Panaja	0	0	54	100	43	79.6	11	20.4
TreVellazen	1	3.2	30	96.8	27	87.1	4	12.9
Total	4	2	196	98	165	82.5	35	17.5
	More than Twice		**Twice or Less**		**Never**		**Do Not Remember**	
	No. of farmers	(%)	No. of farmers	(%)	No. of farmers	(%)	No. of farmers	(%)
Bestrove	9	26.5	9	26.5	14	41.2	2	5.8
Cerkovine	10	22.2	12	26.7	15	33.3	8	17.8
Kanine	3	8.3	0	0	31	86.1	2	5.6
Panaja	11	20.4	4	7.4	36	66.7	3	5.5
TreVellazen	8	25.8	13	41.9	8	25.8	2	6.5
Total	41	20.5	38	19	104	52	17	8.5

Values in parenthesis ( ) represent row percentages.

Table 5.17 Farmers' Contact with a Specialist who Discussed Non-Pesticide Means (NPM) of of Pest Control and Perceived Access to Information Vlora, Albania, 1999.

Villages	Discussed NPM of Pest Control No. of farmers	(%)	Did not Discuss NPM of Pest Control No. of farmers	(%)
Bestrove	7	20.6	27	79.4
Cerkovine	6	13.3	39	86.7
Kanine	3	8.3	33	91.7
Panaja	6	11.1	48	88.9
TreVellazen	4	12.9	27	87.1
Total	26	13	174	87

Villages	Adequate Access to Information No. of farmers	(%)	Inadequate Access to Information No. of farmers	(%)
Bestrove	5	14.7	29	85.3
Cerkovine	15	33.3	30	66.7
Kanine	1	2.8	35	97.2
Panaja	3	5.6	51	94.4
TreVellazen	6	19.4	25	80.6
Total	30	15	170	85

Values in parenthesis ( ) represent row percentages.

Table 5.18 Perceived Importance of Agricultural Information, Innovations, and the roles of State in Agriculture.

Villages	Very Necessary No. of farmers	(%)	Necessary No. of farmers	(%)	Unnecessary No. of farmers	(%)	Do Not Know No. of farmers	(%)
Bestrove	29	85.3	5	14.7	0	0	0	0
Cerkovine	33	73.3	12	26.7	0	0	0	0
Kanine	25	69.4	9	25	2	5.6	0	0
Panaja	35	64.8	19	35.2	0	0	0	0
TreVellazen	24	77.4	6	19.4	0	0	1	3.2
Total	146	73	51	25.5	2	1	1	0.5

Villages	Applied Innovative Practices No. of farmers	(%)	Have not Applied Innovative Practices No. of farmers	(%)
Bestrove	13	38.2	21	61.8
Cerkovine	18	40	27	60
Kanine	18	50	18	50
Panaja	18	33.3	36	66.7
TreVellazen	18	58	13	42
Total	85	42.5	115	57.5

State support to agriculture should be:1

Villages	Stronger than Before '90s 1) No. of farmers	(%)	Same as Before '90s No. of farmers	(%)	Less than Before '90s No. of farmers	(%)	No Support At All No. of farmers	(%)
Bestrove	25	73.5	4	11.8	2	5.9	3	8.8
Cerkovine	36	80	5	11.1	0	0	4	8.9
Kanine	27	75	7	19.4	2	5.6	0	0
Panaja	42	77.8	3	5.5	2	3.7	7	13
TreVellazen	22	71	6	19.3	1	3.2	2	6.5
Total	152	76	25	12.5	7	3.5	16	8

Values in parenthesis ( ) represent row percentages.

1) Refers to the period during the socialist regime when respondents were members of collective farms .

Table 5.19 Adoption of Innovation in Olive Production System. Vlora, Albania, 1999.

	No. of farmers responding in each village					**Total Farmers**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Innovative Practices:						
Light Pruning	13 (38.3)	18 (40)	12 (33.3)	14 (25.9)	15 (48.4)[2]	72 (36)[2]
Heavy Pruning	11 932.4)	8 (17.8)	7 (19.4)	14 (25.9)	15 (48.4)	55 (27.5)
Use of Pest resistant cultivars	1 (2.9)	1 (2.2)	0 (0.0)	1 (1.9)	3 (9.7)	6 (3.0)
Application of trapping methods	0 (0.0)	0 (0.0)	2 (5.6)	1 (1.9)	0 (0.0)	3 (1.5)
Tilling of area under the tree	11 (32.4)	14 (31.1)	11 (30.6)	15 (27.8)	13 (41.9)	64 (32)
Irrigation	0 (0.0)	4 (8.9)	1 (2.8)	0 (0.0)	1 (3.2)	6 (3.0)
Use of sheep/hen against olive fly	1 (2.9)	1 (2.2)	4 (11.1)	0 (0.0)	1 (3.2)	7 (3.5)
Sources of Innovation practices:						
Neighbor/other farmers	0 (0.0)	5 (21.7)	5 (21.7)	8 (34.8)	5 (21.8)1	23 (18.1)[2]
Self/own experience	12 (20)	7 (11.7)	14 (23.3)	17 (28.3)	10 (16.7)	60 (47.2)
Extension specialist	5 (35.7)	2 (14.3)	1 (7.1)	4 (28.6)	2 (14.3)	14 (11)
Research center	0 (0.0)	10 (47.6)	2 (9.5)	2 (9.5)	7 (33.4)	21 (16.6)
University	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0
Written materials/publications	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)	1 (0.8)
Agricultural radio/TV programs	3 (37.5)	1 (12.5)	2 (25)	2 (25)	0 (0.0)	8 (6.3)
Reasons for not applying innovations:						
Haven't really thought about it	3 (8.6)	14 (40)	2 (5.7)	2 (5.7)	14 (40)[1]	35 (17.6)[2]
Can't afford financially	14 (14.6)	20 (20.8)	18 (18.8)	18 (18.8)	26 (27)	96 (48.2)
No access to credit	3 (7.7)	5 (12.8)	9 (23.1)	9 (23.1)	13 (33.3)	39 (19.6)
Would not be economical	3 (33.3)	3 (33.3)	0 (0.0)	0 (0.0)	3 (33.3)	9 (4.5)
Don't know where to get help/advice	4 (20)	2 (10)	2 (10)	2 (10)	10 (50)	20 (10.1)

1) Values in parenthesis ( ) represent row percentages.
2) Values in parenthesis ( ) represent column percentages.

Table 5.20 Olive Pests and Diseases Known by Farmers in Vlora, Albania, 1999.

	No. of farmers responding in each village					**Total Farmers**
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Olive Pests/Diseases known by farmers						
Olive Fly	34 (100)	44 (97.8)	34 (94.4)	48 (88.9)	31 (100)	191 (95.5)
Black Scale	24 (70.6)	23 (51.1)	29 (80.6)	31 (57.4)	26 (83.9)	133 (66.5)
Olive Psyllid	26 (76.5)	33 (73.3)	25 (69.4)	43 (79.6)	22 (71)	149 (74.5)
Olive Moth	14 (41.2)	18 (40)	18 (50)	30 (55.6)	18 (58)	98 (49)
Leaf Spot	17 (50)	16 (35.6)	6 (16.7)	19 (35.2)	13 (42)	71 (35.5)
Olive Knot	23 (67.7)	31 (68.9)	19 (52.8)	36 (66.7)	22 (71)	131 (65.5)
Olive Pests/Diseases known as most damaging by farmers						
Olive Fly	33 (97)	42 (93.3)	28 (77.8)	40 (74.1)	29 (93.6)	172 (86)
Black Scale	12 (35.3)	10 (22.2)	18 (50)	12 (22.2)	7 (22.6)	59 (29.5)
Olive Psyllid	16 (47.1)	9 (20)	6 (16.7)	19 (35.2)	11 (35.5)	61 (30.5)
Olive Moth	4 (11.8)	4 (8.9)	11 (30.6)	19 (35.2)	8 (25.8)	46 (23)
Leaf Spot	8 (23.5)	7 (15.6)	1 (2.8)	9 (16.7)	8 (25.8)	33 (16.5)
Olive Knot	5 (14.7)	11 (24.4)	6 (16.7)	11 (20.4)	8 (25.8)	41 (20.5)

Multiple response since farmers may know more than one pest.
Values in parenthesis ( ) represent percentage of farmers in the village who mentioned the pest/disease.

Table 5.21 Farmers' Knowledge of the Damage Caused by Pests and Diseases on Olives. Vlora, Albania, 1999.

Nature of Damage	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Olive Fly						
Damages tree & leaves	2 (5.9)	0 (0.0)	12 (33.3)	10 (18.5)	5 (16.1)	29 (14.5)
Damages olive fruit	32 (94.1)	42 (93.3)	29 (80.6)	39 (72.2)	30 (96.8)	172 (86)
Black Scale						
Damages tree & leaves	22 (64.7)	24 (53.3)	28 (77.8)	28 (51.9)	24 (77.4)	126 (63)
Damages olive fruit	1 (2.9)	1 (2.2)	3 (8.3)	5 (9.3)	0 (0.0)	10 (5.0)
Olive Psyllid						
Damages tree & leaves	25 (73.5)	32 (71.1)	24 (66.7)	40 (74.1)	22 (71)	143 (71.5)
Damages olive fruit	3 (8.8)	0 (0.0)	3 (8.3)	1 (1.9)	0 (0.0)	7 (3.5)
Olive Moth						
Damages tree & leaves	8 (23.5)	11 (24.4)	13 (36.1)	12 (22.2)	14 (45.2)	58 (29)
Damages olive fruit	7 (20.6)	10 (22.2)	11 (30.6)	24 (44.4)	3 (9.7)	55 (27.5)
Leaf Spot						
Damages tree & leaves	14 (41.2)	16 (35.6)	6 (16.7)	18 (33.3)	14 (45.2)	68 (34)
Damages olive fruit	2 (5.9)	0 (0.0)	1 (2.8)	0 (0.0)	0 (0.0)	3 (1.5)
Olive Knot						
Damages tree & leaves	20 (58.8)	29 (64.4)	17 (47.2)	31 (57.4)	22 (71)	119 (59.5)
Damages olive fruit	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.7)	0 (0.0)	2 (1.0)

Multiple responses since farmers may report more than one damage caused by pests.
Values in parenthesis ( ) represent percentage of farmers in the village who mentioned the damage.

Table 5.22 Olive Pests and Diseases Observed by Farmers Last Season. Vlora, Albania, 1999.

	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Olive Pests/Diseases observed						
Olive Fly	32 (94)	39 (86.7)	31 (86.1)	44 (81.5)	31 (100)	177 (88.5)
Black Scale	8 (23.5)	6 (13.3)	18 (50)	11 (20.4)	8 (25.8)	51 (25.5)
Olive Psyllid	17 (50)	12 (26.7)	21 (53.3)	18 (33.3)	11 (35.5)	79 (39.5)
Olive Moth	4 (11.8)	4 (8.9)	9 (25)	22 (40.8)	10 (32.3)	49 (24.5)
Leaf Spot	9 (26.5)	5 (11.1)	3 (8.3)	12 (22.2)	9 (29)	38 (19)
Olive Knot	10 (29.4)	9 (20)	7 (19.4)	14 (26)	5 (16.1)	45 (22.5)
Most Important Olive Pests/Diseases						
Olive Fly	30 (88.1)	40 (90)	30 (83.3)	31 (57.4)	28 (90.4)	159 (79.5)
Black Scale	2 (5.9)	2 (4.4)	1 (2.8)	3 (5.6)	1 (3.2)	9 (4.5)
Olive Psyllid	1 (3.0)	1 (2.2)	1 (2.8)	5 (9.3)	0 (0.0)	8 (8.0)
Olive Moth	0 (0.0)	0 (0.0)	3 (8.3)	10 (18.5)	1 (3.2)	14 (7.0)
Leaf Spot	1 (3.0)	0 (0.0)	0 (0.0)	3 (5.6)	0 (0.0)	4 (2.0)
Olive Knot	0 (0.0)	2 (4.4)	1 (2.8)	2 (3.6)	1 (3.2)	6 (3.0)
Second Most Important Olive Pests/Diseases						
Olive Fly	0 (0.0)	1 (2.2)	4 (11.1)	6 (11.1)	2 (6.5)	13 (6.5)
Black Scale	12 (35.3)	16 (35.6)	18 (50)	14 (25.9)	8 (25.8)	68 (34)
Olive Psyllid	12 (35.3)	9 (20)	3 (8.3)	8 (14.8)	6 (19.3)	38 (19)
Olive Moth	4 (11.8)	9 (20)	5 (13.9)	10 (18.5)	5 (16.1)	33 (16.5)
Leaf Spot	4 (11.8)	5 (11.1)	0 (0.0)	7 (13)	9 (29)	25 (12.5)
Olive Knot	2 (5.8)	5 (11.1)	6 (16.7)	9 (16.7)	1 (3.3)	23 (11.5)

Multiple response since farmers may have observed more than one pest in olives last season.
Values in parenthesis ( ) represent percentage of farmers in the village who observed the pest/disease.

Table 5.23 Farmers' Awareness of Beneficial Insects and Animals in their Olive Groves. Vlora, Albania, 1999.

	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Aware	4 (11.8)	8 (17.8)	19 (52.8)	18 (33.3)	6 (19.4)	55 (27.5)
Not Aware	5 (14.7)	1 (2.2)	7 (19.4)	22 (40.7)	2 (6.5)	37 (18.5)
No opinion	25 (73.5	36 (80)	10 (27.8)	14 (25.9)	23 (74.2)	108 (54)
Effects of Pesticides *\\ on Natural Enemies						
All are killed/die	0 (0.0)	1 (2.2)	2 (5.6)	2 (3.7)	1 (3.2)	6 (3.0)
Some are killed/die	2 (5.6)	5 (11.1)	10 (27.8)	7 (13)	4 (13)	28 (14)
Decrease in number	3 (8.8)	5 (11.1)	6 (16.7)	6 (11.1)	4 (13)	24 (12)
Nothing happens	0 (0.0)	0 (0.0)	1 (2.8)	3 (5.6)	0 (0.0)	4 (2.0)
Don't know	5 (14.7)	10 (22.2)	4 (11.1)	1 (1.9)	6 (19.4)	26 (13)

*\ There were not many farmers who responded to this question.
Values in parenthesis ( ) represent percentage of farmers in the village who perceived each effect.

Table 5.24 Attitudes Toward Pesticides, Olive Pest and their Management. Vlora, Albania, 1999.

Villages	**No. of farmers (%)**		**No. of farmers (%)**		**No. of farmers (%)**	
	Must use chemicals to control pests/diseases		**No need for Chemical control**		**No opinion**	
Bestrove	31	91.2	2	5.9	1	2.9
Cerkovine	43	95.6	0	0	2	4.4
Kanine	35	97.2	0	0	1	2.8
Panaja	53	98.2	1	1.8	0	0
TreVellazen	31	100	0	0	0	0
Total	193	96.5	3	1.5	4	2
	Pesticides increase yield		**Pesticides do not increase yield**		**No opinion**	
Bestrove	14	41.2	0	0	20	58.8
Cerkovine	21	46.7	0	0	24	53.3
Kanine	25	69.4	2	5.6	9	25
Panaja	22	40.8	0	0	32	59.2
TreVellazen	16	51.6	0	0	15	48.4
Total	98	49	2	1	100	50
	Pesticides can hasten pest infestation		**Pesticides will not hasten pest infestation**		**No opinion**	
Bestrove	6	17.7	0	0	9	26.5
Cerkovine	11	24.4	0	0	12	26.7
Kanine	18	50	4	11.1	5	13.9
Panaja	10	18.5	6	11.1	5	9.3
TreVellazen	7	22.6	3	9.7	4	12.9
Total	52	26	13	6.5	35	17.5

Values in parenthesis ( ) represent percentage of farmers in the village who perceived each effect.

Table 5.25 Control Measures Taken Against Olive Pests and Diseases Last Season. Vlora. Albania. 1999.

Control Measures		**No. of farmers responding in each village**					**Total Farmers**
		Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Apply Pesticide		7 (20.6)	11 (24.4)	5 (13.9)	19 (35.2)	3 (9.7)	45 (22.5)
Mechanical Method		5 (14.7)	1 (2.2)	5 (13.9)	3 (5.6)	2 (6.5)	16 (8.0)
Pruning		24 (70.6)	37 (82.2)	32 (88.9)	47 (87)	27 (87.1)	167 (83.5)
Tilling of Area under the Tree		22 (64.7)	36 (80)	26 (72.2)	45 (83.3)	28 (0.3)	157 (78.5)
No control		9 (26.5)	6 (13.3)	7 (19.5)	9 (16.7)	3 (9.7)	34 (17)
Used Pesticides in:							
Fruit Tr.:	Yes	4 (11.8)	3 (6.7)	4 (11.1)	4 (7.4)	3 (9.7)	18 (9.0)
	No	30 (88.2)	42 (93.3)	32 (88.9)	50 (2.6)	28 (0.3)	182 (91)
Citrus:	yes	2 (5.9)	8 (17.8)	1 (2.8)	1 (1.9)	2 (6.5)	14 (7.0)
	No	32 (94.1)	37 (82.2)	35 (97.2)	53 (98.1)	29 (93.5)	186 (93)
Vineyar.:	Yes	17 (50)	15 (33.3)	13 (36.1)	36 (66.7)	11 (35.5)	92 (46)
	No	17 (50)	30 (66.7)	23 (63.9)	18 (33.3)	20 (64.5)	108 (54)

Multiple response since farmers may use more than one control measure.
Values in parenthesis ( ) represent percentage of farmers in the village who used the control methods.

Table 5.26 Farmers' Reasons for Pesticide Use in Olives. Vlora, Albania, 1999.

Villages	**To Prevent Pest and Disease Infestation**		**To Control Pest and Disease Infestation**	
	No. of farmers	**(%)**	**No. of farmers**	**(%)**
Bestrove	3	42.9	4	57.1
Cerkovine	6	54.6	5	45.4
Kanine	4	80	1	20
Panaja	12	63.2	7	36.8
TreVellazen	3	75	1	25
Total	28	60.9	18	39.1

Multiple response since farmers may give more than one reason.
Values in parenthesis ( ) represent row percentages.

Table 5.27 Farmers' Perceptions of Pesticides' Effects on Human Health/Environment. Vlora, Albania, 1999.

Perception	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Pesticides can harm water quality:						
Agree	14 (41.2)	11 (24.4)	10 (27.8)	15 (27.8)	11 (35.5)	61 (30.5)
Disagree	6 (17.7)	4 (8.9)	17 (47.2)	19 (35.2)	8 (25.8)	54 (27)
Don't know	14 (41.2)	30 (66.7)	9 (25)	20 (37)	12 (38.7)	85 (42.5)
Farms' water supply contaminated by pesticides:						
Agree	2 (5.9)	0 (0.0)	5 (13.9)	3 (5.6)	3 (9.6)	13 (6.5)
Disagree	17 (50)	11 (24.4)	23 (63.9)	33 (61.1)	14 (45.2)	98 (49)
Don't know	15 (44.1)	34 (75.6)	8 (22.2)	18 (33.3)	14 (45.2)	89 (44.5)
Attribute health problems of family members to pesticides:						
Agree	2 (5.9)	1 (2.2)	4 (11.1)	5 (9.3)	5 (16.1)	17 (8.5)
Disagree	18 (52.9)	23 (51.1)	28 (77.8)	41 (75.9)	14 (45.2)	124 (62)
Don't know	14 (41.2)	21 (46.7)	4 (11.1)	8 (14.8)	12 (38.7)	59 (29.5)

Values in parenthesis ( ) represent column percentages.

Table 5.28 Perception of the Importance of Factors Affecting Choice of Pesticides. Vlora, Albania, 1999.

	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Reasons for not applying pesticides						
Price of Pesticides is high	25 (73.5)	30 (66.7)	30 (83.3)	39 (72.2)	23 (74.2)	147 (73.5)
I'm not sure about the quality of pesticides	18 (52.9)	25 (55.6)	23 (63.9)	30 (55.6)	21 (67.7)	117 (58.5)
Pesticides are not available locally	4 (11.8)	2 (4.4)	4 (11.1)	12 (22.2)	1 (3.2)	23 (11.5)
Don't know how to apply pesticides	5 (14.7)	8 (17.8)	11 (30.6)	9 (16.7)	8 (25.8)	41 (20.5)
Don't have a spraying equipment	16 (47.1)	15 (33.3)	16 (44.4)	27 (50)	18 (58.1)	92 (46)
Have no idea about pest control practices	5 (14.7)	5 (11.1)	11 (30.6)	10 (18.5)	5 (16.1)	36 (18)
Olive is not that important as a farm activity	1 (3.0)	1 (2.2)	1 (2.8)	3 (5.6)	0 (0.0)	6 (3.0)
Other farmers don't apply pesticides	6 (17.7)	12 (26.7)	16 (44.4)	25 (46.3)	8 (25.8)	67 (33.5)

Factors affecting choice of pesticides	No. of farmers responding			
	Not Important	**Somewhat Important**	**Very Important**	**Extremely Important**
Pesticide Cost	4 (2.0)	18 (9.0)	57 (28.5)	110 (55)
Agric. Specialist's advice	5 (2.5)	10 (5.0)	94 (47)	67 (33.5)
Pesticide Dealer advice	14 (7.0)	31 (15.5)	66 (33)	23 (11.5)
Neighbor's advice	12 (6.0)	21 (10.5)	67 (33.5)	9 (4.5)
Safety	10 (5.0)	14 (7.0)	51 (25.5)	29 (14.5)

Multiple response since farmers may mentioned more than one reason.
Values in parenthesis ( ) represent column percentages.

Table 5.29 Sprayer Ownership among Farmers. Vlora, Albania, 1999.

Variables	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Own a sprayer:[1]						
Yes	25 (73.5)	28 (62.2)	12 (33.3)	32 (59.3)	13 (42)	110 (55)
No	9 (26.5)	17 (37.8)	24 (66.7)	22 (40.7)	18 (58)	90 (45)
If Not. where do they get one:[2]						
Borrow	2 (22.2)	6 (35.3)	6 (25)	3 (13.6)	5 (27.8)	22 (24.4))
Rent	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.6)	1 (5.6)	2 (2.2)
Hired Laborer provides a sprayer	0 (0.0)	0 (0.0)	4 (16.7)	4 (18.2)	2 (11.1)	10 (11.1)
Use no sprayer	7 (77.8)	11 (64.7)	14 (58.3)	14 (63.6)	10 (55.5)	56 (62.3)
Type of the sprayer own by farmers:[2]						
Knapsack	15 (44.1)	28 (62.2)	10 (27.8)	32 (59.3)	9 (29)	94 (47)
Hand Sprayer	7 (20.6)	0	2 (5.6)	0	2 (6.5)	11 (5.5)
Tractor Pump	3 (8.8)	0	0	0	2 (6.5)	5 (2.5)

1Values in parenthesis ( ) represent percentage of farmers in the village who own a sprayer.
2 Values in parenthesis ( ) represent column percentages.

Table 5.30 Decision-Making Roles in the Family. Vlora, Albania, 1999.

Role/Responsibility	No. of farmers responding in each village					Total Farmers
	Bestrove	Cerkovine	Kanine	Panaja	TreVellazen	
Financial decision on pesticide expenditure:						
Husband/brother	21 (61.8)	36 (80)	32 (88.9)	40 (74.1)	27 (87.1)	156 (78)
Wife/sister	0 (0.0)	0 (0.0)	1 (2.8)	1 (1.8)	1 (3.2)	3 (1.5)
Both husband & wife	13 (38.2	9 (20)	3 (8.3)	13 (24.1)	3 (9.7)	41 (20.5)
Purchaser of Pesticides:						
Husband/brother	27 (79.4)	39 (86.7)	33 (91.7)	51 (94.4)	30 (96.8)	180 (90)
Wife/sister	2 (5.9)	2(4.4)	0 (0.0)	0 (0.0)	0 (0.0)	4 (2.0)
Both husband & wife	5 (14.7	4 (8.9)	3 (8.3)	3 (5.6)	1 (3.2)	16 (8.0)
Pest management decisions:						
Husband/brother	26 (76.5)	40 (88.9)	31 (86.1)	44 (81.5)	27 (87.1)	168 (84)
Wife/sister	0 (0.0)	2 (4.4)	0 (0.0)	0 (0.0)	1 (3.2)	3 (1.5)
Both husband & wife	8 (23.5)	3 (6.7)	5 (13.9)	10 (18.5)	3 (9.7)	29 (14.5)
Agricultural product marketing decisions:						
Husband/brother	20 (58.8)	34 (75.6)	31 (86.1)	43 (79.6)	22 (71)	150 (75)
Wife/sister	0	8 (17.8)	0	1 (1.9)	1 (3.2)	10 (5)
Both husband & wife	14 (41.2)	3 (6.6)	5 (13.9)	10 (18.5)	8 (25.8)	40 (20)

Values in parenthesis ( ) represent column percentages.

Table 5.43 Harvest timing vs Dimethoate (40%) - minimum practice scenario

Added benefits		LEK	USD		
Added revenue		26206	187.2		Derived from more yield, quality
	Yield gain	16270	116.2		improvement, cost and labor savings
	Quality gain	9936	71.0		
Reduced cost		2220	15.9		
	Insecticide use	1440	10.3		
	labour of applicator	780	5.6		
Total Added Benefits		28426	203.0		
Added costs					
Added cost					
		0	0.0		
Reduced revenue					
		0	0.0		
Total Added Cost		0	0.0		
Net Added Benefits		28426	203.0		

Table 5.44 Straw mulching, plowing, and cover crop vs Diuron (50%) and Glyphosate (36%) - minimum practice scenario

Added benefits		LEK	USD		
Added revenue		21238	151.7		Derived from more yield, quality
	Yield gain	16270	116.2		improvement, cost and labor savings
	Quality gain	4968	35.5		
Reduced cost		2793.6	20.0		
	Insecticide use	2419.2	17.3		
	labour of applicator	374.4	2.7		
Total Added Benefits		24032	171.7		
Added costs					
Added cost		13554	96.8		
	Materials	7500	53.6		Material cost and labor used
	Labor	4554	32.5		in the intervention
	Fuel and lube	1500	10.7		
Reduced revenue					
		0	0.0		
Total Added Cost		13554	96.8		
Net Added Benefits		10478	74.8		

Note : Yield and quality gain estimates are adjusted using the probability of research success

Table 5.45 Pruning and optimal timing of copper spray vs copper sprays only - min. pract. scenario

Added benefits		LEK	USD				
Added revenue		17636	126.0		Derived from more yield, quality		
	Yield gain	17636.4	126.0		improvement, cost and labor savings		
	Quality gain	0.0	0.0				
Reduced cost		0.0	0.0				
Total Added Benefits		17636	126.0				
Added costs							
Added cost		9840.8	70.3		Material and labor costs		
	Pruning tools and labor	500	3.6				
	Insecticide use	6220.8	44.4				
	labour of applicator	3120	22.3				
Reduced revenue							
		0	0.0				
Total Added Cost		9840.8	70.3				
Net Added Benefits		7796	55.7				

Table 5.46 Pheromone vs Dimethoate (40%) - minimum practice scenario

Added benefits		LEK	USD				
Added revenue		35148.6	251.1				
	Yield gain	21486.6	153.5		Derived from more yield, quality		
	Quality gain	13662	97.6		improvement, and labor saving		
Reduced cost		4584	32.7				
	Insecticide use	3024	21.6				
	labour of applicator	1560	11.1				
Total Added Benefits		39732.6	283.8				
Added costs							
Added cost		17040	121.7				
	Pheromone (1/tree)	16800	120.0		Material cost used in the intervention		
	labour of applicator	240	1.7				
Reduced revenue							
		0	0.0				
Total Added Cost		17040	121.7				
Net Added Benefits		22692.6	162.1				

Table 5.47 "Milking" vs "Beating" harvesting method - minimum practice scenario

Added benefits		LEK	USD		
Added revenue		16643	118.9		
	Yield gain	16643	118.9		Derived from more yield and quality
	Quality gain	0	0.0		improvement
Reduced cost					
		0	0.0		
Total Added Benefits		16643	118.9		
Added costs					
Added cost		9770	69.8		
	Harvesting tools	49.5	0.4		Material cost and labor used
	labor	9720	69.4		in the intervention
Reduced revenue					
		0	0.0		
Total Added Cost		9769.5	69.8		
Net Added Benefits		6873	49.1		

Table 5.48 Irrigation vs no irrigation - minimum practice scenario

Added benefits		LEK	USD		
Added revenue		46326.6	330.9		
	Yield gain	46326.6	330.9		Derived from more yield and
	Quality gain		0.0		quality improvement
Reduced cost					
		0	0.0		
Total Added Benefits		46326.6	330.9		
Added costs					
Added cost		3353	24.0		
	Labor	1872	13.4		Material cost and labor used
	Irrigation water	1200	8.6		in the intervention as well as
	Irrigation system	281	2.0		additional costs for irrigation
					system
Reduced revenue					
		0	0.0		
Total Added Cost		3353	24.0		
Net Added Benefits		42973.6	307.0		

Appendix E

The cost structure of IPM CRSP/Albanian Project

The costs of olive IPM CRSP/Albanian program include project-related expenditure incurred by American and Albanian collaborating institutions (American universities, FTRI, PPRI, and AUT) for olive IPM technology development and dissemination.

The list of scientists from the U.S. and Albanian institution involved in research and management activities of IPM CRSP/Albania program is as follows:

The U.S. IPM CRSP/Albania Team:

Charlie Pitts, Pennsylvania State University
Doug Pfeiffer, Virginia Tech
Greg Luther, Virginia Tech
Daniel Taylor, Virginia Tech
Lefter Daku, Virginia Tech
Milt McGiffen, University of California, Riverside
Louise Ferguson, University of California, Davis
Beth Teviotdale, University of California, Davis

The Albanian IPM CRSP/Albania Team:

AUT
Fadil Thomaj, Horticulture
Myzejen Hasani, Phytopathology
Rexhep Uka, Entomology
Magdalena Bregasi, Agricultural Economics

FTRI
Dhimiter Panajoti, Olive Specialist
Bardhosh Ferraj, Production Techniques
Hajri Ismaili, Olive Specialist (Breeding)
Jaho Nelaj, Production Techniques
Mendim Baci, Phytopathology
Uran Abazi Olive Specialist
Zaim Veshi, Extension specialist

PPRI
Enver Isufi, Entomology
Brunilda Stamo, Quarantine / Certification
Bujar Huqi, Vegetation Management
Ejup Cota, Entomology
Harallamb Bace, Phytopathology
Josef Tedeskini, Entomology
Skender Varaku, Entomology

It is assumed that each year the U.S. scientists contribute 5% of their time to IPM CRSP/Albania project and that their average annual salary is $75,000. The Albanian scientists contribute 35% of their time to the project and their average annual salary is 308,000 lek or $2,200. Based on these assumptions, the project-related annual expenditure for the scientists involved are as follows:

American scientists: 8 scientists @ $75,000 * 5% * 4 yrs (1999-2002)
= $120,000
Albanian scientists: 18 scientists @ $2,200 * 35% * 4 yrs (1999-2002)
= $ 55,440

The above expenditures are in addition to $600,000 USAID grant money spent for the project during the period 1999-2002. Another element of the project cost structure is the expenditure needed for dissemination of the research results. Generally speaking, most of the dissemination of research results cost should be born by the public extension service. However, given the present undeveloped structure of this service in Albania, the collaborating Albanian research and education institutions will have to play a crucial role in the efforts for dissemination of IPM CRSP research results especially in non-target areas. For this purpose, an additional $200,000 is assumed to cover expenditures related to field demonstrations and local trials in both target and non-target zones. Based on the above assumptions, the total project cost for olive IPM technology development and dissemination is $975,440. Based on the project expenditure structure for 1999-2001, the total cost of IPM research is broken down for each research experiment using the following shares: 29% to experiment 1, 22% to experiment 2, 21% to experiment 3, and 28% to experiment 4.

Appendix F

Brief Notes on Logit Model

The binary logit formulation is one method used to operationalize random utility theory, which assumes that people always select the alternative with the highest utility, but that utility can not be measured perfectly. Rather, the utility of an alternative, U_i, can be separated into deterministic, V_i, and random components, e_i, in other words, $U_i = V_i + e_i$. The deterministic portion can then be assumed to be a linear combination of independent variables, $V_i = \mathbf{b'x}$, where $\mathbf{b}$ is a vector of parameters to be estimated. The binary logit model states that the probability of choosing any alternative i is equal to the probability that the utility of alternative i is greater than the utility of alternative j (where j is not equal to i). The mathematical formulation is given below:

$$Pr(i) = Pr[U_i >= U_j] = \exp[\mathbf{b'x}] / (\exp[\mathbf{b'x}] + \exp[\mathbf{b'x}])$$

Where:

Pr(i) - the probability of choosing i
i - any particular alternative
U_i - utility of alternative i
m - a scale parameter

Let $\pi(x) = E(Y|x)$ represent the conditional mean of Y given x when logistic distribution is assumed. The specific form of the logistic regression model is as follows:

$$h(x) = \frac{e^{b_0+b_1x}}{1+e^{b_0+b_1x}} \qquad (E.1)$$

A transformation of $\pi(x)$, called the logit transformation is defined in terms of $\pi(x)$ as follows:

$$g(x) = \ln\left[\frac{h(x)}{1-h(x)}\right] = b_0 + b_1x \qquad (E.2)$$

The importance of this transformation is that g(x) has many of the desirable properties of a linear regression model. The logit, g(x), is linear in its parameters, may be continuous, and may range from -∞ to +∞, depending on the range of x (Hosmer and Lemeshow, 1989)

Major features of the logit model include the following:

- The conditional mean of the regression equation must be formulated to be bounded between zero and one. The logistic regression model, $\pi(x)$, given in equation (1) above satisfies this constraint.
- The binomial, not the normal, distribution describes the distribution of the errors and will be the statistical distribution upon which the analysis is based.
- The principles the guide an analysis using linear regression will also guide us in logistic regression.

Log likelihood function for a logistic model is:

$$L(b) = \sum_{i=1}^{n} \left\{ y_i \ln[h(x_i)] + (1 - y_i) \ln[1 - h(x_i)] \right\} \qquad \text{(E.3)}$$

To find the value of β that maximizes *L(B)* we differentiate *L(B)* with respect to β_0 and β_1 and set the resulting expression equal to zero.

Testing for the significance of the model

Under hypothesis that an individual coefficient is zero, the univariate Wald test statistics, $W_j = \hat{b}_j / S\hat{E}(\hat{b}_j)$ will follow the standard normal distribution. A critical value of 2, which would lead to an approximate level of significance of 0.05, is used to test for the significance of parameter estimates.

Considering that the overall goal is to obtain the best fitting model while minimizing the number of parameters, a reduced form of the model is fitted containing only those variables thought to be significant and compare it to the full model containing all the variables.

The overall significance of the model with the *p* coefficients for explanatory variables is tested using the likelihood ratio test. The test is based on the statistics LR given as follows:

$$LR = -2(\ln L(\hat{q}_u) / \ln L(\hat{q}_r) \qquad \text{(E.4)}$$

with u and r denoting unrestricted and restricted models respectively.[77]

Because the log likelihood (LL) is negative, the –2LL is positive, and larger values indicate worse prediction of the dependent variables.

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[77] The reason why log likelihood is multiplied by –2 is that this allows the statistic to have approximately chi-square distribution

The value of $-2LL_R$ for the logistic regression model with only the intercept included is called "Restricted log likelihood" in LIMDEP logistic regression. This intercept-only $-2LL_R$ is analogous to the total sum of square, SST, in linear regression analysis. The value of $-2LL_F$ for the logistic regression model that includes the independent variables as well as the intercept is called "Log likelihood function" in LIMDEP logistic regression. The value of $-2LL_F$ for the full model is analogous to the error sum of square, SSE, in linear regression models. The $-2LL_F$ is used in logistic models as an indicator of how poorly the model fits with all of the independent variables in the regression equation. Hence, maintaining the analogy with linear regression, the statistical significance of $-2LL_F$ (Log likelihood function) is analogous to the statistical significance of the *unexplained* variance in a linear regression model. The difference $G = [(-2LL_R) - (-2LL_F)]$ is called the model chi-square in LIMDEP logistic regression and is analogous to the regression sum of square, SSR, in linear regression models. G is also analogous to the multivariate F test for linear regression.

Under the null hypothesis that the restriction holds, i.e., the *p* coefficients for the explanatory variables in the model are equal to zero ($\beta_1=\beta_2=\ldots=\beta_k=0$), the LR statistic is asymptotically distributed as chi-square with *p* degrees of freedom equal to the number of (independent) restrictions on the parameter vector. For example, consider the fitted model of IPM adoption using the 1999 data set. For that model, the value of the log likelihood is L = -112.667, the value of restricted log likelihood is L = - 135.257. Hence, the test statistics G is:

$G = -2\,[(-135.257) - (-112.667)] = -2\,(-22.59) = 43.18$

Which is significant at the $\alpha = 0.10$ level. By failing to accept the null hypothesis, it can be concluded that at least one and perhaps all *p* coefficients are different from zero.

Measuring goodness-of-fit of the logit model

David and Lemeshow (1989) proposed the use of G and R_L^2 based on $-2LL$ statistics to test how well the model fits the data. The R_L^2 is computed using log-likelihood values from logistic regression as follows:

$$R_L^2 = \left(\frac{L_0 - L_p}{L_0}\right)100 = \left(1 - \frac{L_p}{L_0}\right)100 \qquad \text{(E.5)}$$

where L_0 and L_p denote the log-likelihood values for model containing only the intercept and the full model, respectively. However, as David and Lemeshow (1989) explained the R_L^2 is nothing more than an expression of the likelihood ratio test and, as such, is only an approximation of goodness-of-fit measure. This is because the likelihood ratio test compares fitted values under two models rather than comparing observed values to those fitted under one model.

Significance level of parameter estimates

Any variable whose univariate test has a p-value <0.25 should be considered as a candidate to be included in the model. Use of the 0.25 level as a screening criterion for selection of candidate variables is based on the work by Bendel and Afifi (1977) on linear regression and on the work by Mickey and Greenland (1989) on logistic regression. These authors show that use of a more traditional level (such as 0.05) often fails to identify variables known to be important. Setting significance criterion for inclusion in a range from 0.15 to 0.25 results in an increased risk of rejecting the null hypothesis when it is true (finding a relationship that is not really there) but a lower risk of failing to reject the null hypothesis when it is false (not finding a relationship that really is there).

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Vita

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