Cost-Effectiveness Evaluation of Integrated Pest Management (IPM) Extension Methods and Programs: The Case of Bangladesh

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ABSTRACT

This study evaluates the cost-effectiveness of alternative Integrated Pest Management (IPM) training methods and programs aimed at diffusing IPM innovations to farmers in Bangladesh. Various IPM innovations are categorized as being simple, intermediate or complex, while dissemination methods used to extend these innovations are classified as being less intense, moderately intense, or more intense. Examples of less intense diffusion methods include mass media and field day demonstrations, and moderately intense methods include visits from agents. A "farmer field school" (FFS) is considered a more intense type of training method. The study evaluates the effectiveness of these IPM diffusion methods based on a number of criteria such as a methods ability to reach the greatest number of farmers with a given budget, their capability of reaching farmers quickly, and their ability to influence adoption of IPM. Additional components of effectiveness include influencing appropriate use of IPM, influencing retention of IPM, providing a level knowledge that participants can adapt to other areas on the farm, and providing accessibility to limited resource farmers. Data used in the analysis come from a field survey conducted on 350 rice and vegetable farmers in Bangladesh during July and August of 2004. Three ordered probit models are used to measure adoption of simple, intermediate and complex technologies. Results from these models indicate that FFS participants are more likely than non-participants to adopt simple, intermediate and complex practices, while farmers visited by agents are more likely than non-participants to adopt simple and intermediate practices. Field day attendees are more likely to adopt intermediate and complex practices than non-participants. These results may be influenced by endogeneity of unobserved factors that influence participation in FFS but also affect adoption. The study uses a binary probit model to measure appropriate use, but it does not detect any significant difference in appropriate use among farmers trained through different methods, nor does it find any significant differences in retention rates among farmers who have been to different training programs. Another probit model identifies farmers who have been visited by an agent as being more likely to discover an IPM practice through their own experimentation, indicating that farmers who have been visited by an agent have received enough knowledge to adapt IPM to different problems on their farm. Results of the study indicate that limited resource farms are well represented by their participation in the various training methods, but that a higher percentage of large farmers than small farmers in the sample have been visited by an agent or been to FFS. Informal diffusion of IPM information is found to be occurring among people in FFS villages for simple practices. However, for intermediate and complex practices, farmers who participated in FFS are no more likely to spread information to other people in their villages than are less intense formal training methods such as field days and agent visits. This result indicates that while FFS graduates may be likely to share simple practices with others, they should not be relied upon as the primary means of informally diffusing more complex practices to other farmers. The cost-effectiveness estimation incorporates components of the effectiveness evaluation along with the cost of administering the methods. The study calculates that agent visits are the most cost-effective method for diffusing simple and complex technologies and practices, while field days are the most cost-effective methods for extending intermediate technologies and practices.

Dedication

I dedicate this work to my four grandparents, Mary & Charles Gilbert and Virginia & Ralph Ricker. I appreciate all of your love and support over the years.

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CHAPTER I: INTRODUCTION

I.1 Problem Statement

New agricultural technologies and practices are important contributors to agricultural growth in developing countries. When innovations improve farmers' production practices by increasing yields or profit, farmers receive this information, through formal institutions, informal social networks, and their own trial and error (Conley and Udry (2000): Bindlish and Evenson (1997); Rogers 1995). The process of diffusing information to farmers, whether conducted by government agencies, Non Government Organizations (NGO) or agricultural universities, must be done in the most cost-effective manner possible in order to ensure that the training and dissemination programs are sustainable and the funding from sponsoring institutions continues.

Farmers in Bangladesh need information on innovations that can help them combat pests that damage their crops. Harmful pests include insects, pathogens, weeds and organisms that may reduce crop production. Pests are one of the major inhibitors to increasing agricultural productivity in Bangladesh, and according to an estimate from the Bangladesh Ministry of Agriculture, insect pests alone cause annual yield losses of 16% for rice, 11% for wheat, 25% for vegetables, 15% for jute and 25% for pulses (Bangladesh Ministry of Agriculture, 2002).

Pests are detrimental to Bangladesh agriculture and producers are always searching for new ways to minimize the damage that they cause. For many years pesticides were the principal weapons that many Bangladesh farmers used to manage certain pests that attacked their crops. Prior to 1974, pesticides were completely subsidized by the government and available to farmers free of charge. Although the subsidy was reduced to 50% in 1974 and then eliminated in 1979, the government's pro pesticide policies during this time encouraged an unsustainable pattern of behavior in which farmers learned to use certain chemicals in excessive and indiscriminant amounts.

Numerous studies, including Maumbe and Swinton (2003); Fernandez-Cornejo (1998); and Harper and Zilberman (1992), demonstrate that pesticide misuse is harmful to human health and the environment. Furthermore, dependence on agricultural chemicals can lead to increased pest resistance to pesticides (Norton et al. 2005). Fortunately agricultural research continues to combat farmer dependence on pesticides by creating innovations and developing strategies to manage pests while reducing the volume of chemical input needed to control them. Integrated Pest Management (IPM) is one such sustainable strategy for controlling pests. The United Nations Food and Agricultural Organization, defines IPM as follows;

> A pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury .

Integrated Pest Management strives to manage pest populations at a level that maintains or enhances producer profits while minimizing environmental and health damages (Wetzstein, et. al, 1985). IPM tries to suppress pests to an acceptable level rather than striving for complete annihilation. Pests should be reduced to a level that is economically feasible for farmers, while taking human health and the environment into consideration.

Farmers in Bangladesh receive a great deal of information about pests from many different sources. Some of these sources provide farmers with conflicting information. For example, although pesticides are no longer subsidized by the government, privately owned pesticide companies still operate throughout the country. Pesticide dealers continually provide farmers with strategies and products that promote the use of chemicals. Directors of IPM training programs must work overcome the influence of pesticide dealers order to facilitate farmers using sustainable IPM practices.

This study examines how IPM knowledge and innovations are diffused to farmers in Bangladesh and evaluates the most cost-effective method or combination of methods available to disseminate that information. Rogers (1995) describes diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). Verbs such as, extend, diffuse, disseminate, train and transfer are all used in this study to represent the process of communicating ideas between members of a social system, as described by Rogers. The term method in this study describes the different types of training programs through which farmers obtain information about IPM. Examples of methods used to diffuse IPM information to farmers in Bangladesh include mass media instruments such as the radio, television or print media, field day demonstrations, visits from extension agents, and the participatory learning approach know as farmer field school (FFS).

Farmers receive knowledge about specific IPM practices and technologies from various methods that they can apply to their production process. Institutions that are involved in extending IPM information to farmers through various methods include domestic agricultural institutions such as the Bangladesh Agricultural Research Institute (BARI) and The Department of Agricultural Extension (DAE) along with Non Governmental Organizations (NGO)'s such as The Cooperative for Americans Reaching Everywhere (CARE) and the USAID funded IPM Collaborative Research Support Program (CRSP). All of these institutions have limited funding so evaluating different methods based on their cost-effectiveness is important for the sustainability of the programs. Effectiveness of different methods is measured based on a set of criteria that a particular method should possess in order to be considered effective or desirable. The effectiveness of each method is weighed against the cost of diffusing information to farmers in order to create an overall measure of cost-effectiveness for the IPM diffusion methods.

Measuring cost-effectiveness of extending IPM practices is complex and can be evaluated on different levels. The various IPM practices and technologies can be categorized based on the level of knowledge that adopters must possess in order to successfully implement them on their farms. These practices and technologies require knowledge that can range from simple to complex. For a simple practice or technology to be successfully implemented, a farmer need only possess a limited understanding of the technology and be able to follow a prescribed set of instructions. In contrast, for a practice or technology requiring complex knowledge to be incorporated on a farm, the farmer must possess some degree of management ability, and an awareness of the agricultural eco-system that exists on a farm.

While IPM practices and technologies are categorized based on complexity, IPM diffusion methods can also be categorized by training intensity. At one end of this intensity continuum are less intense methods such as mass a media radio broadcast. A broadcast lasts for a short time and farmers are instructed how to use a specific IPM technology or practice. Less intense methods help create awareness of IPM that may lead to farmers seeking further knowledge from other sources. A type of method that is more intense than a mass media radio broadcast is a field day demonstration. Field days may last an entire day or for several consecutive days. The use of extension personnel, trained in IPM, who visit farmers for several hours at a time, is a different type of method that could be classified as a moderately intense training method. Farmer field schools (FFS) are an example of training methods that can be classified as more intense. FFS generally take place for several hours a day, once a week for ten to fifteen weeks during a growing season. There is a tradeoff between highly-intensive participatory training programs such as FFS that train and empower a relatively small number of farmers to make informed decisions about IPM and less-intensive IPM programs such as field days which train a greater number of farmers but provide perhaps a shallower level of understanding per farmer trained (Norton el al., 2005).

FIGURE 1.1
CONTINUUM OF IPM TECHNOLOGIES & TRAINING METHODS

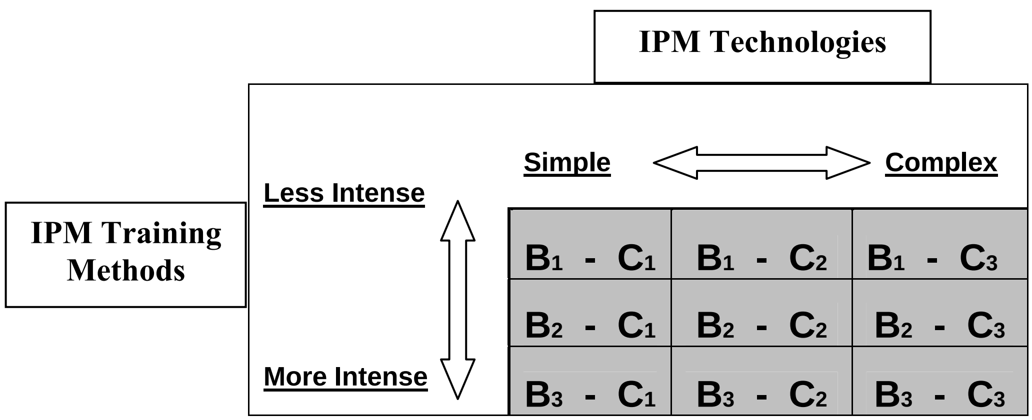


Figure 1.1 illustrates the relationship between the different types of IPM technologies and the methods used to extend them to farmers. The figure demonstrates that technologies ranging from simple to complex may be transferred by methods that vary from less to more intense. When a technology is extended to a farmer by a particular method, that farmer may gain some benefit from learning about, adopting and using that technology or practice appropriately. When considering cost-effectiveness of diffusing a technology through a particular method, the cost (C) of bringing the technology to farmers through that method is subtracted from the benefit (B) of extending the technology through that method. For each technology, practice, or bit of information there is some method or combination of methods that extends it most cost-effectively.

Several criteria should be considered when evaluating the effectiveness of different methods at diffusing IPM knowledge to farmers. The first criterion is to determine how many farmers each method reaches and number of farmers reached for a given budget. The difficulty in measuring effectiveness with respect to the number of people trained is in calculating the informal diffusion or the secondary spread of information from farmers who have been reached by a particular method to other farmers in their social network who have not attended the training. Prior studies have shown that informal, social learning can be difficult to measure due to data limitations (Conley and Udry, 2000). There is evidence to suggest that farmers will adopt a technology if they observe one of their neighbors or peers having success using it (Rogers, 1995). Gotland et al. (2004) discusses how informal diffusion of IPM knowledge in communities where IPM trainings have occurred can underestimate the impact of a training program that has taken place there. When farmers disseminate information to others in the community who did not attend the training, the benefits of the program are extended beyond those who participated, and the program is thus more effective.

Empirical attempts to measure the informal transfer of IPM knowledge have had mixed results. Price (2000) finds evidence of secondary transfer of information in a Philippine village where a farmer field school occurred. In Price's study, those farmers who did not participate in the farmer field school show increased knowledge of IPM practices after the field school had taken place, indicating that they received information from FFS graduates in the village through an informal network. Conversely, Rola et al. (2002), finds no significant difference in IPM knowledge between farmers in the Philippines who did not participate in FFS, even though it occurred in their village, and farmers who lived in a different village with no farmer field school. Feder et al. (2004B) finds no significant evidence that FFS trained farmers share IPM information with their neighbors in Indonesia. While the effects of secondary spread of IPM knowledge and practices through informal social networks are uncertain, it is an important consideration when determining how many people a method reaches, and it s important in determining cost-effectiveness.

In addition to reaching a large number of farmers with a given budget, an effective method is also able to spread information quickly. Information that is spread quickly and efficiently maximizes the amount of time that a message will be useful to farmers. If an IPM practice, such as information about how to combat a disease is useful for only a short period of time, then rapid spread of information is crucial to the effectiveness of that technology.

Effectiveness not only depends on how many farmers receive information about a technology through a particular method, but also on how successful that training program is at influencing farmers to adopt IPM after attending the training. Institutions that extend IPM to farmers incur costs whenever they conduct training so when a farmer attends a training session and learns about a technology but chooses not to adopt it, the potential benefit from that technology is lost and resources are wasted. Adoption of IPM practices in many countries may be limited due to "technical, institutional, social, cultural economic, educational, informational, and public constraints" (Norton et al. 2005, pp. 4). Therefore methods that increase the probability that someone will actually adopt an IPM practice must be identified and promoted. Mauceri (2004), studying IPM adoption for potato farmers in Ecuador, concludes that FFS participation is the most significant factor in influencing adoption of IPM, followed by field days and then pamphlets. Additional research is needed to investigate which formal IPM training methods influence the adoption of various practices and technologies.

Farmers who adopt a technology or practice must implement and use it in an appropriate manner, so determining which methods train farmers in a way that encourages correct use of a technology is important. If farmers do not receive correct instructions on how to use a technology, the longevity, usefulness and benefit of the technology may be jeopardized.

A cost-effective training method must also provide farmers with the skills to retain knowledge over time. If a farmer becomes aware of a technology through a particular type of training, and then adopts it, but does not receive enough training or understanding of the technology to use it properly over a number of years, the method can not be considered effective at influencing retention of knowledge over time. Previous literature indicates that farmers who have experienced intensive, participatory programs such as farmer field schools have higher levels of knowledge and retain information longer than those not exposed to any transfer method (Feder et. al. 2004A; Rola et al. 2002). While several studies have measured retention rates for graduates of farmer field schools, little to no investigation has been conducted to see whether other methods, such as field days or agent visits provide farmers with adequate knowledge so that they are able to retain IPM information as well as or better than FFS graduates.

Another issue to be considered is which methods provide farmers with the depth and understanding of IPM so that participants are able to adapt and transfer their knowledge from one situation to another on the farm. This problem solving component requires that farmers be able to recognize problems and deal with different situations that occur on the farm. Rola et al. (2002) found that FFS graduates had significantly greater levels of knowledge about pest management and nutrition management practices then non FFS graduates in a separate village. Feder et al. (2004B) had concluded similar findings in Indonesia. Further investigation needs to be conducted to compare the problem solving and analytical skills of farmers who have been to FFS with those who have participated in other methods.

The final component in measuring the effectiveness of IPM diffusion methods is examining if farmers with limited resources have access and are able to participate in different types of IPM training methods. A general problem associated with the transfer of technology is that innovations are often developed for and diffused to progressive rather than marginal farmers. Progressive farmers are more likely to be educated, and have higher incomes, thus they have the power to influence research institutions causing the development of technologies to be skewed in their favor (Roling, 1988). According to the Statistical Yearbook of Bangladesh (2001) close to 98% of Bangladeshi farmers cultivate 3.03 hectares or less. If the different diffusion methods such as field days, extension visits and FFS are to have any impact on promoting IPM, small farmers with limited resources must be able to attend these trainings and learn about IPM practices and technologies.

The effectiveness components described above are combined with the cost of administering the different methods in order assess overall cost-effectiveness of IPM training methods. Although previous studies have evaluated farmer field schools, in various parts of the world, additional work is needed to compare the effectiveness of different methods at extending IPM technologies and practices to farmers. Conducting a cost-effectiveness analysis of IPM dissemination methods is particularly important because in many developing countries such as Bangladesh, extension and training programs receive limited funding and support so maintaining cost-effective programs are vital for the sustainability of IPM education.

I.2 Objectives

The specific objectives of this study are to:

1. Evaluate the cost-effectiveness of alternative methods or combinations of methods at disseminating different IPM technologies to farmers based on the following criteria.

   A) Reaches the greatest number of farmers with a given budget.

   B) Spreads information quickly.

   C) Influences farmers to adopt IPM technologies and practices.

   D) Influences farmers use IPM technologies and practices in an appropriate manner.

   E) Provides participants with enough understanding so they are able to retain knowledge of IPM practices over time.

   F) Participants obtain a depth of understanding so they are able to adapt and transfer IPM knowledge from one situation to another on the farm.

   G) Accessible to limited resource farmers.

2. Create an overall measurement of cost-effectiveness for each method by weighing the benefits, measured in increased profit to the farmers, of each method against the cost of reaching farmers with that method.

I.3 Hypotheses

Testable Hypotheses

1. There is no significant difference in probability of IPM adoption among farmers who have been trained through different methods.

2. Farmers trained through more intense methods are no more likely to use technology in an appropriate manner than farmers trained through less intense methods.

3. Farmers trained through more intense methods have no higher retention rates than farmers trained through less intense methods.

4. Farmers who learn about IPM practices through more intense methods are no more likely to adapt and apply the knowledge to other situations on their farm than farmers trained through any other method.

5. Farmers of limited resources are no more likely to attend less intense methods than they are to attend any other method.

I.4 Procedures and Data Sources

The study uses regression analyses based on a field survey of 350 respondent farmers in four different regions of Bangladesh. The respondents are grouped based on their participation in different IPM training methods. The regression analysis includes the respondents' various socio-economic characteristics to ensure that the effectiveness of the different IPM training methods is accurately estimated. Data on cost is obtained through budget information and interviews with people working for the institutions that coordinate IPM training methods. Data on national aggregate production quantities and prices is collected from various statistical yearbooks and databases on Bangladesh.

I.5 Organization of Thesis

The thesis is divided into five chapters. Chapter 2 discusses the background for the study by explaining the IPM diffusion methods, IPM technologies, and IPM policies in Bangladesh. Chapter 3 outlines the methodology used for the analysis. Chapter 4 describes the results of the models measuring effectiveness of IPM dissemination methods and presents the costs of administering each method. Chapter 4 then estimates the overall cost-effectiveness of extending various IPM practices and technologies to farmers through different methods. Chapter five concludes the thesis and provides a summary and closing discussion on the topic.

CHAPTER II: BACKGROUND

II.1 Introduction

Chapter two provides background information on the economy, and agricultural sector in Bangladesh. The chapter also discusses pest management and the institutions responsible for extending IPM to farmers. IPM training methods that are evaluated in this study along with the different technologies and practices that are included in the cost-effectiveness analysis are also presented in chapter two.

II.2 Bangladesh Economy

Bangladesh is located on the Indian subcontinent and is bordered by India, Myanmar and the Bay of Bengal. Much of Bangladesh is situated on a low lying delta plane where nearly 700 rivers, the largest of which, the Ganges, the Jamuna and the Meghna Rivers empty into the Bay of Bengal and the Indian Ocean. Every year during the monsoon season many of the rivers overflow, flooding nearly one third of the country. The flood water is essential for agricultural cultivation, but during years of excessive flooding many homes and crops are destroyed and lives are lost.

Bangladesh is relatively small in land area with only 133,910 square kilometers making it roughly the size of the state of Iowa (U.S. CIA, 2004). It has a large and growing population of over 140 million making it one of the most densely populated countries in the world with more than 1,000 people per square kilometer. National GDP is $258.8 billion adjusted for purchasing power parity with a per capita GDP of $1,900 adjusted for ppp. Agriculture composes 21% of GDP, industry 26.6% of GDP and services makes up 51.7% of GDP. Agriculture employs 63% of the labor force, industry 11% and services 16% respectively. A great deal of Bangladesh's excess labor force finds employment through emigration to the Arabian Peninsula, Malaysia, Singapore and other countries. Workers remittance between 1998 and 1999 is estimated to have been US$ 1.71 billion (U.S. CIA, 2004).

The Bangladesh economy grew at a rate of 3.39% per year between 1981 and 1994. It continued to grow around 4% per year in the mid 1990's and at around 5% in the late 1990's and into the new millennium (Mahmud, 1998; U.S. CIA, 2004). Real per capita GDP increased by 14% between 1960 and 1980 and by 65% between 1980 and 2000. Unemployment remains high and the national deficit in 2003 was 43.3% of GDP. The economy must continue to grow if it is to provide employment and food for its population which is increasing by 2.08% per year.

II.3 Bangladesh Agricultural Sector

Agriculture is fundamental to the economy of Bangladesh. According to Pierre Landell-Mills, Country Director of the World Bank in Bangladesh, agriculture is the key to overall economic performance in Bangladesh. It is essential for poverty alleviation and generates a majority of the country's foreign exchange earnings (Faruqee, 1998).

The majority of farms in Bangladesh are small in size with land holdings averaging between .83 and 1.43 hectares in 1998 (Bangladesh Ministry of Planning, 2000). Rice is the principle crop with almost 75% the nation's farm land dedicated to its cultivation. Other important crops include pulses, wheat, jute, fruits and vegetables. As Bangladeshi's population continues to grow, the amount of additional land available to be brought into cultivation will be limited while at the same time demand for food from a growing population puts pressure on the agricultural sector to increase output.

II.3.1 Rice Production

Rice is the by far most important crop in Bangladesh as about 90% of Bangladesh's population consumes it as its principal food source. In 1995-1996, rice comprised 13% of the agricultural sector's GDP (Banglapedia.com, 2004). Rice is cultivated during three seasons in Bangladesh, Aman, Boro and Aus. The Aman season occurs between December and January. The Boro season takes place between March and May and the Aus season occurs between July and August. During 1997-1998 5.87 million hectares were devoted to Aman cultivation, 2.89 million hectares to Boro, and 1.56 million hectares to Aus (Banglapedia.com, 2004).

Rice production in Bangladesh grew substantially after independence from Pakistan in 1971 until the mid 1990's. Rice yields grew at a rate of 1.49% per year between 1973/74 - 1983/84 and at a rate of 2.56% per year between 1979/80 and 1990-91. According to Mahmud (1998) a majority of the growth in rice productivity can be attributed to the introduction of High Yielding Varieties (HYV). Growth in rice productivity and agricultural productivity has stagnated since the 1990's, and Mahmud attributes this decline in growth to factors including agronomic constraints, lack of production technologies, lack of farm level incentives, and market supply and demand imbalances. These issues must be overcome however if agricultural growth and economic growth is to continue in Bangladesh.

II.3.2 Vegetable Production

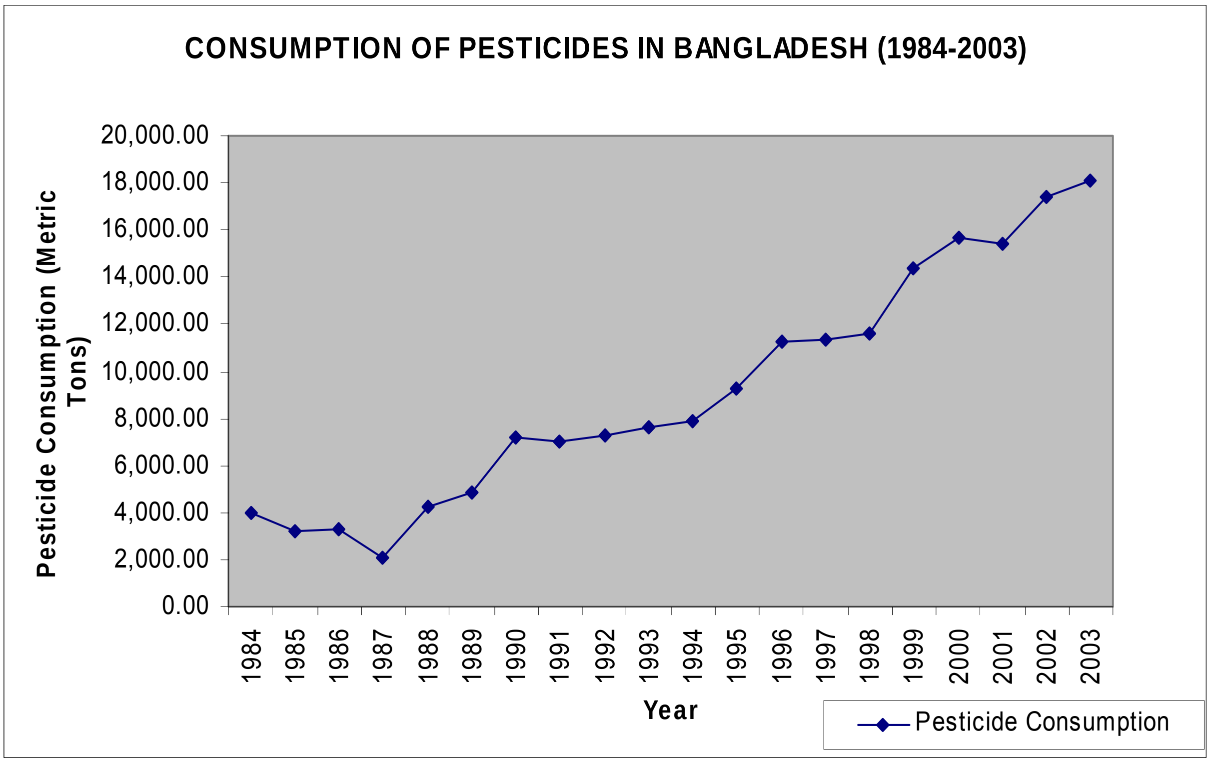
Vegetables are an important part of the Bangladeshi diet. Although vegetables only comprise 1.39% of cultivated land in Bangladesh they are a valuable source of nutrition for many people. Many poor Bangladeshis cultivate vegetables on small homestead plots in order to feed their families. Eggplant is one of the most commonly cultivated vegetables in Bangladesh. Eggplant is available all year round and is often one of the only vegetables affordable for poor people in urban areas. Other widely grown vegetables include tomatoes, cabbage and various types of gourds.

II.3.3 Pest Management

Rice and vegetables in Bangladesh suffer relentless attacks from many different types of pests. As mentioned in chapter one, pest damage in Bangladesh reduces yields by an estimated 16% for rice, 11% for wheat, 25% for vegetables, 15% for jute and 25% for pulses (Bangladesh Ministry of Agriculture, 2002). Insects that attack rice include rice hispa, rice bug, stem borer, brown plant hopper and green leaf hopper. Diseases that infect rice include bacterial leaf blight, blast, brown spot, stunt disease and tungro. Eggplants are attacked by insects such as leafhopper, fruit and shoot borer, root not nematode and are susceptible to diseases such as bacterial wilt. Tomatoes are also vulnerable to bacterial wilt and root knot nematode. Cucurbits and gourds are vulnerable to the fruit fly and cabbage yields are lost due to Lepidopteran pests. Weeds are also a major pest that damage rice and vegetables.

The Bangladesh government once viewed pesticides as the most viable way to control pest infestation in some crops, so prior to 1974 pesticides were available to farmers at a 100% subsidy. The subsidy was completely removed in 1979 but Bangladesh farmers continue to use pesticides today. Figure 1 clearly demonstrates that pesticide use has been on the increase over the years since the subsidy was removed. Pesticide use is especially high in vegetables such as eggplant which receives an estimated 1.41 kilogram of pesticides per hectare, compared to rice which takes only 0.2 kilograms of pesticides per hectare (Alam, 2003).

Figure 2.1



(Source: Pesticide Association of Bangladesh)

Pesticides can be harmful to human health and the environment. In order to combat these problems, the FAO implemented the first IPM training program in 1981 and since that time, other organizations such as CARE, UNDP, DANIDA, and USAID have all established IPM education programs in Bangladesh (Abubakar, 2002).

The Bangladesh government has realized the importance of Integrated Pest Management for the country's future. For that reason, in 2002 the Ministry of Agriculture set out to develop a national IPM policy. The goal of the initiative, which will occur between 2005 and 2016, is to train 1.7 million farmers on IPM or roughly 20% of the estimated 8.26 million pesticide-using households in Bangladesh. The total budget for the project is estimated to be over US$ 46.5 million, with a majority of the funding coming from the government of Denmark (Bangladesh Ministry of Agriculture, 2004).

II.4 IPM Extension Institutions

When agricultural innovations are developed domestically in Bangladesh, they are mainly generated by one of eleven government research institutions or in some instances they are created by one of five agricultural universities. The research institutions such as the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Rice Research Institute (BRRI) are under the control of the Ministry of Agriculture, while the Ministry of Education oversees the universities. The research organizations are formally required to conduct research while the universities are dedicated to teaching so university faculty are not explicitly required to conduct research although many choose to do so (Hamid, 2004).

Research organizations and agricultural universities also disseminate technologies on a relatively small scale, however the major institutions responsible for extending IPM technologies are the Department of Agricultural Extension (DAE) run by the Ministry of Agriculture and a number of Non Governmental Organizations (NGO)'s such as CARE and the IPM CRSP. There are numerous other smaller entities, such as Bangladesh Academy for Rural Development (BARD), and the Bangladesh Agricultural Development Corporation (BADC) that are engaged in transferring IPM technologies to farmers. Although they are all separate autonomous organizations, government organizations and NGOs often work in cooperation to coordinate farmer training in different regions of Bangladesh.

II.4.1 Department of Agricultural Extension (DAE)

The Department of Agricultural Extension (DAE) is the largest formal institution responsible for extending IPM to farmers in Bangladesh. The organization's headquarters are in Dhaka but has its nearly 24,000 employees stationed throughout Bangladesh. A collaborative project known as the DAE-DANIDA Strengthening Plant Protection Services (SPPS) is the most comprehensive IPM training program in Bangladesh. The project receives the majority of its funding from The Danish International Development Agency (DANIDA) while it is administered by the DAE. The DAE provides the training and the agents to bring IPM to farmers throughout the country. The first phase of the SPPS project ran between 1997 and 2002 and successfully trained several thousand farmers on IPM. The project is currently operating in phase II, which began in 2002. By the conclusion of phase II in 2006 the DAE and DANIDA intend to have trained 117,000 rice and 78,000 vegetable farmers on IPM (Bangladesh Ministry of Agriculture, 2003A).

The SPPS program will be run under the third phase of the DAE-DANIDA SPPS project and it plans to continue to use farmer field schools as the principal method for extending IPM to farmers. By 2016 the DAE hopes to have implemented 69,000 FFS training 1.7 million farmers in every region of the country (Bangladesh Ministry of Agriculture, 2004).

II.4.2 Cooperative for American Relief Everywhere (CARE)

The Non Governmental Organization CARE has been operating in Bangladesh since the 1950's, with the goal of reducing poverty. CARE conducts training programs in a variety of areas including agricultural development, health care, sanitation, local government, women's advocacy. CARE Bangladesh has implemented IPM programs dealing with crop husbandry such as No-Pest and GO-Interfish along with programs encouraging farmers to use IPM in homestead gardens. The CARE training is primarily based in the northern districts of Bangladesh which has long been the poorest and most neglected region of the country. The CARE programs focus on helping 221,375 of the poorest Bangladeshi's, many of whom are illiterate, 80% of whom are female and who generally have little to no land to cultivate other than homestead plots (Den Tex, 2004).

The newest phase of the CARE IPM program in Bangladesh is called the Rural Livelihoods Program (RLP). IPM is one component of this program, along with sanitation and health. The CARE model for the RLP training utilizes the FFS method, but unlike the DAE FFS, the CARE program lasts for up to two years rather then for a single growing season. CARE also provides credit and works to create sustainable access to markets for its trainees. Through providing training and resources in different areas such as IPM, credit, and market access, CARE creates a technical package through their RLP that has the potential to improve the lives of many of Bangladesh's rural poor (CARE Bangladesh, 2004).

II.4.3 IPM Collaborative Research Support Program (CRSP)

The USAID funded IPM CRSP has been operating in Bangladesh since 1998. This project involves cooperation between researchers from the United States and Bangladesh. The IPM CRSP site in Bangladesh is located at BARI and works to develop, adapt, and diffuse IPM technologies and practices. The IPM CRSP focuses on vegetable IPM as pesticides use is very high on vegetable production in many parts of Bangladesh. Among the technologies and practices developed and adapted to Bangladesh by the IPM CRSP and BARI scientists are eggplant and tomato grafting to overcome bacterial wilt, best management practices for weeding and the introduction of pheromone traps for combating the fruit flies that attack cucurbits and gourds.

The IPM CRSP has a partnership with CARE to disseminate IPM technologies to farmers. The IPM CRSP trains CARE personnel, who then extend the practices and knowledge to farmers. The IPM CRSP also provides its own training to farmers through field day demonstrations, and visits from CRSP personnel.

II.5 IPM Training Methods

The different institutions in Bangladesh utilize a variety of methods to diffuse IPM knowledge and practices to farmers. These methods range from less intense instruments such as mass media, that provide a basic level of understanding but train a relatively large number of farmers per dollar spent to very intense methods such as farmer field schools that provide a deep understanding of IPM but train a relatively small number of farmers per dollar spent on the program.

II.5.1 Mass Media

Mass media methods include print media such as newspapers, leaflets and bulletins that provide IPM information to farmers. These printed methods give farmers a general knowledge of IPM practices, are inexpensive to produce and transmit but do not provide great depth of knowledge. Mass media can also transmit information to farmers quickly where other more intensive methods may take longer for messages to spread.

Methods such as radio broadcasts and television programs are more intense than printed media. Radio broadcasts and television programming with agricultural themes occur nearly every day in Bangladesh for an hour or two at a time. These methods also have the potential to reach a wide audience and can cover topics in more depth then print media.

The Bangladeshi government and the DAE state that they plan to use mass media in their national IPM policy as a way to educate both producers and consumers about the importance of IPM and the dangers of pesticides (Bangladesh Ministry of Agriculture, 2004). Targeting both producers and consumers is essential in order to increase the likelihood that IPM practices are adopted.

While mass media can potentially reach many people in a short time period, one of its limitations is its inability to reach the entire population of Bangladesh. Print media is limited in the number of people it can reach in Bangladesh because only 43.1% of the population is literate. The difficulty in reaching people with television and radio is that while it can reach illiterate people, there are many Bangladeshi's particularly in rural areas without electricity making access to television difficult and impossible. Despite these limitations, Mass media is still a viable method for reaching a large segment of the population quickly and with a relatively low average cost per farmer reached.

II.5.2 Field Day Demonstrations

Field days are an example of a method that is more intense than mass media. The typical field day demonstration lasts for one day or several days. During an IPM field day, experts come to a village and put on demonstrations to introduce new IPM technologies or practices to farmers. Field days in Bangladesh are sponsored by the Ministry of agriculture, the DAE, IPM CRSP or any number of NGO's or other international organizations.

Several hundred farmers may attend a field day demonstration. The benefit of field days is that a large number of farmers can receive information about an IPM technology or practice at the same time. The field day provides more depth of understanding about specific practices for farmers than does mass media, because participants are able to observe the IPM innovations first hand. The costs associated with field days include salaries of the experts that administer the event, the opportunity cost of the trainers' time, transportation for the experts to the event, and cost of food and refreshment for participants and the field day and the opportunity cost of participants' time.

II.5.3 DAE Extension Visits

Extension agents living in villages and visiting local farms individually and in group meetings is perhaps the oldest and most common extension method in the world. In Bangladesh the DAE employs an extension agent known as the Block Supervisor (BS) in every union (a clustering of two or three villages) in the country. In 2003 Bangladesh employed 10,280 field level block supervisors and was looking to increase the field level staff to 12,640 (Ministry of Agriculture, 2003C). The BS lives in the union where he works and his job is to provide farmers with information and training about new agricultural technologies and practices.

The transactions cost of having extension agents visit farmers is very low because the agents live in close proximity to the farmers with whom they work. The costs of the agent visits include paying the agents' salaries and providing them with training along some food and transportation costs. The drawbacks to this system are that it is insufficiently funded so it is impossible for extension personnel to interact with every farmer. Extension personnel are overextended in many parts of the country, for example in 2003 there were approximately 18 million farm households in Bangladesh, in 2003 meaning that there was roughly one extension agent for every 1,750 farm households (Ministry of Agriculture, 2003C). It is also difficult to monitor block supervisors and provide them with incentives to actually work with the farmers. Furthermore, the quality of extension agents varies as does their ability to connect with farmers and influence them to adopt new practices and technologies.

II.5.4 Farmer Field Schools

Farmer field schools are currently being promoted by many development organizations such as the Food and Agricultural Organization (FAO) as the most appropriate method for disseminating IPM technologies and information in developing countries. The first FFS began in the 1980's in Java Indonesia, teaching farmers about rice IPM. The DAE run FFS and the FFS administered by CARE are two different types of FFS training methods that are being conducted in Bangladesh. While they have notable differences, there are common attributes among all farmer field schools. The principal component of any FFS is that it emphasizes experiential learning, with a participatory approach. Hands-on training is important to attract both literate and illiterate farmers and to keep them interested in learning about IPM. FFS curriculum calls for establishing IPM trials in farmers' fields and demonstration plots to show the benefits of IPM through observation and experimentation (Feder, et al. 2004B). Farmer field schools are run by facilitators rather than instructors in order to create a group learning environment rather than a classroom setting with a teacher giving instructions. Farmer Field Schools are based on the premise that farmers already posses sizeable knowledge about farming so the FFS Curriculum strives to incorporate principles of IPM into farmers understanding and create an awareness for farmers of the agro-ecological system that exists on their farms (Den Tex, 2004).

The DAE farmer field schools are designed to train farmers about IPM practices for a specific crop such as rice or numerous vegetables such as eggplant, gourd, and cabbage. The typical DAE run FFS is conducted by four trained facilitators made up of, one Agricultural Extension Officer (AEO) or Additional Agricultural Officer (AAO), one Plant Protection Inspector (PPI) and two Block Supervisors. Each DAE FFS is set up to train 25 farmers in 14 sessions that meet once a week during an entire growing season (Bangladesh Ministry of Agriculture, 2003A).

The CARE FFS differs from the DAE FFS in that it lasts for two years rather than for one growing season. It is also a more comprehensive training program in that IPM is just one of several components covered in their training. CARE trains 25 farmers per FFS and is designed specifically for illiterate and female farmers many of whom are engaged in only vegetable cultivation and have no land to grow rice. As mentioned before, CARE also provides participants with credit and access to markets for their crops.

The FFS system is an intense IPM training method. The benefits of farmer field schools are that they provide participants with a great depth of understanding about IPM. Numerous empirical studies including two conducted in Bangladesh by Larsen et al. (2002a) looking at rice and Larsen et al. (2002b) studying vegetables show strong impacts of FFS. Both studies compare yields and pesticide use between FFS trained farmers and non-FFS trained farmers and the findings indicate that FFS trained farmers have higher yields and lower pesticide use than non trained farmers. The weakness of the two Larsen studies are that they do not properly control for selection bias for farmers who choose to participate in FFS, nor to they account for the other factors that influence yields and pesticide use, such as education and income.

Godtland et al. (2004) investigating FFS for potato farmers in the Peruvian Andes controlled for selection bias and other factors influencing IPM knowledge and yield, using a matching propensity score model. The researchers conclude that FFS participants have significantly more knowledge about IPM then those who did not participate in FFS. The study also concluded that increased agricultural knowledge leads to higher yields and FFS participants are more likely than non participants to have higher output on their farms.

The argument against farmer field schools is that while the farmers who attend FFS training may receive a deep and substantial understanding of IPM, training only 25 farmers in a village is not enough to have a significant impact. More farmers might be reached with the same amount of money if a less intensive method is employed. A study conducted by Feder et al. (2003) using time series data in Indonesia finds no significant difference in change in yields or pesticide use when comparing FFS participants with non participants. Another study by Feder et al. (2004) finds that that FFS trained farmers had a greater knowledge of IPM than non FFS farmers, but that knowledge of IPM is not spreading to farmers in villages with FFS who did not attend the training. Quizon et al. (2001) find that the average cost for training a farmer about IPM through FFS was US $47.50 in Indonesia and US $62.00 in the Philippines. These findings are significant because if FFS graduates do not share their knowledge of IPM with their neighbors, then the lack of secondary spread and the high cost of training farmers through FFS calls into question whether Farmer Field Schools are cost-effective and can be a sustainable method for diffusing IPM at a national level.

II.5.5 IPM Clubs

Farmer field schools will have a sustainable impact of spreading IPM only if those farmers who attend FFS continue to use the IPM knowledge they receive after the formal training ends. For this reason the DAE attempts to have each of their FFS turn into a self-sustaining IPM club. The IPM club is less intense than a FFS and serves as a forum for farmers to meet and discuss pest problems and to create further awareness about Integrated Pest Management by encouraging farmers who did not attend the FFS to join the club. The DAE project allocates only 150 taka (US$2.50) for each IPM club, so the club members are encouraged to engage in some income generating activities such as purchasing livestock or organizing a system of micro-credit. The DAE sends agents to the different clubs throughout the year to provide support and encouragement. The DAE also hopes that if the club can be successful, and can generate some profits, it will attract other members of the village to join and learn about IPM (Bangladesh Ministry of Agriculture, 2003). If the club becomes successful and is beneficial to farmers, perhaps they will be willing to pay dues to belong to the club making it a sustainable organization.

The concept of an IPM club has many benefits, such as requiring little financial support from the government and encouraging farmers other than the original 25 FFS trainees to join the club and adopt IPM practices. The problems with IPM clubs are that without any substantial funding, it is difficult for the club to establish its self and purchase necessities such as materials and supplies, and create a clubhouse for holding meetings. The success of the IPM club also depends entirely on the initiative of the farmers in the community. Finally because it is a club, the organization will always remain exclusive in some way and it will be unlikely that everyone in the village will join the club and learn about IPM.

II.6 IPM Technologies and Practices in Bangladesh

Numerous IPM technologies and practices have been developed over the years in Bangladesh. The specific technologies and practices for rice and vegetables that are evaluated in this thesis are categorized as either being simple, intermediate or complex. The categorization of these technologies and practices are based on the degree of understanding of IPM and the management skills that a farmer must possess in order to successfully implement them on his or her farm. For a simple approach to be successfully implemented a farmer needs only to be able to follow a prescribed set of instructions. In contrast, for a practice requiring complex knowledge to be incorporated on a farm, the farmer must possess some degree of management ability, and an awareness of the agricultural eco-system that exists on a farm.

Certain technologies can also be classified as product-based where the technology may be embedded in a product that is purchased by a farmer. A grafted eggplant seedling is an example of a product-based technology that would be classified as a simple technology if the product were purchased by a farmer from a nursery, because the farmer would need only to plant the already grafted eggplant in his or her field. If the farmer grafts his or her own eggplants, then it could be considered a complex practice because the farmer would need to have the ability to select the appropriate root stock and do the grafting procedure by him or herself.

II.6.1 Simple Technologies

Pest Resistant Varieties

For the past several decades, researchers have been working to develop pest-resistant varieties for rice, eggplants, tomatoes and other crops. Pests such as green leaf hopper and caseworm along with different blights such as *tungro* and *sheath* cause damage to rice that reduce yield. Eggplants and tomatoes are infected with bacterial wilt, and attacked by fruit and shoot borer, and root-knot nematode (IPM CRSP, 2001). Collaborative efforts continue to be established among different institutions to develop and extend resistant varieties to farmers.

Sweeping and Handpicking of Pests

Pest populations and pest damages may be greatly reduced in rice by using nets to sweep pests such as rice hispa, rice bug, green leafhopper, brown plant hopper and caseworm off of the rice plant. Pests can also be reduced in cabbage by hand picking pest eggs and caterpillars off leaves. Traditional farmer practices for dealing with these pests are to apply chemical pesticide, however simple practices of using nets and hands greatly reduces production cost to farmers by eliminating the need to apply chemicals. One drawback with handpicking pest off of cabbage is that the practice is labor intensive as pests must be removed from the broad leaves and the head of the plant twice a week beginning 12-15 days after planting for 4-5 weeks until the head of the cabbage has formed (Hoque and Uddin, 2003).

Placing Branches in the Field

Placing tree branches in the rice field can reduce the pest population by allowing birds to perch and eat the harmful insects that attack rice. This simple practice has existed for many years and is an inexpensive practice that may be implemented as part of an IPM strategy for rice.

Reduced Spraying in Rice

An important component of IPM is to reduce application of pesticides in the rice field. Messages that pesticides should not be applied or should be applied only as a last resort when all other options have been exhausted are one way to spread this essential practice for farmers to follow. An example of this type of message or practice is that rice plants should not be sprayed with insecticide for the first 45 days after transplanting and after that time insecticide should only be applied sparingly.

II.6.2 Intermediate Technologies

Hand Weeding

Weeds are a major problem for farmers. It is estimated that weeds cause up to 25% loss in crop yields (Karim and Khan, 2003). Weeds compete with the crops for nutrients, sunlight, and space. Many plants are not able to compete with aggressive weeds. In Bangladesh as well as in many other countries with an abundance of cheap and available labor, weeds are cleared by hand or by hoe. In vegetables, where many farmers weed their crops excessively, the process can be uneconomical as weeding occurs more often than necessary.

Through on-farm research trials, scientists at the Bangladesh Agricultural Research Institute (BARI) have been able to suggest the best times during the growing season for weeding different crops, so as to minimize labor time while reducing yield loss due to weeds. For cabbage, best management practices have been found to be two hand weedings at 15 and 35 days after transplanting, which maximizes yields and cuts costs by 18 percent. For okra, two hand weedings are most efficient at 15 and 35 days after emergence of the plant. Three hand weedings, at 21, 35, and 49 days after transplanting have been found to be most efficient for tomatoes.

Clipping Infected Rice Leaves

Pesticide applications can also be reduced in rice by clipping the leaves of the plant that are attacked by rice hispa. Pests such as hispa bore into the leaves of the plant to lay their eggs.

This damage can be harmful initially to the rice plant but once the granula of the plant has formed, damage to the leaves does not affect the plant's yield. Clipping the rice leaves is a relatively easy practice that, while costing some labor time, can reduce pesticide use and minimize pest damage.

Soil Amendments

Vegetable seedlings are relentlessly attacked by soil borne diseases such as damping off, root knot nematode, foot and root rot, and stem blight. Fortunately various soil amendments are available to combat these diseases. Applying poultry refuse or mustard oil cake to the soil kills soil borne diseases and increases soil fertility (Den Tex, 2004). Applying sawdust to the seedbed and burning it to kill the micro-organisms in the soil is another beneficial practice. Sun solarization is an additional IPM practice that can kill pathogens in the soil. During solarization farmers wet the seed bed to make mud and then cover it with white polyethylene sheets and left alone for three weeks. During this time temperatures rise up to over 40 degrees Celsius, destroying the micro-organisms that damage crops (Rahman, 2003).

Pheromone and Bait Traps in Gourds

Fruit flies are a common pest that damages gourds. Using pheromone traps and mashed sweet gourd traps are alternatives to applying pesticides to kill fruit flies. Pheromone is the female sex hormone and it is placed inside of a plastic trap to attract and kill male fruit flies. This technology is user friendly and need only be changed once every two months (Den Tex, 2004).

Although less effective than pheromone, traps filled with mashed sweet gourds are also effective at reducing fruit fly damage in gourds. Mashed sweet gourd traps require more attention than pheromone traps as they must be changed every three days to remain effective (Nasiruddin, 2003). The cost for the pheromone and mashed sweet gourd traps are minimal compared to the cost of applying pesticides. The problem with farmers adopting pheromone traps is that the pheromone is currently not available in many parts of Bangladesh.

II.6.3 Complex Technologies

Eggplant/Tomato Grafting

Two of the most important and commonly grown vegetables in Bangladesh are eggplant and tomatoes. Bacterial wilt and root–knot nematode are detrimental to both of these crops. Scientists have found that wild *solanum* rootstocks are highly resistant to bacterial wilt so they have devised a procedure to graft 40 to 50 day old *solanum* rootstock seedlings with eggplant and tomato seedlings. These grafted seedlings are productive, sturdy and resistant to bacterial wilt and root knot nematode. Trials at BARI, showed that 95% of grafted eggplants survived attacks from these pests (Rashid, et al, 2003). There is a potential market for grafted eggplant seedlings that could be sold to farmers. This industry has yet to be developed and is limited due to the lack of available clips used to join the rootstock seedlings with the eggplant seedlings. Were this market to be developed, eggplant grafting could then be classified as a simple product based technology because farmers would only have to purchase the grafted seedling and would not need to understand the grafting procedure.

Biological Controls

According to Nasiruddin and Alam (2003) nearly every insect pest, especially field crop pests have natural biological enemies. For example eggplant fruit and shoot borer has nearly 20 natural enemies, including 16 parasitoids, and three pathogens. Insect pests of rice such as rice hispa, gall midge and brown plant hopper have many natural enemies such as damsel flies, dragon flies, lady beetles, birds and various types of spiders. Applying pesticides in an attempt to kill harmful pests also exterminates many of the beneficial organisms that prey on the pests. Without the suppression of natural enemies, pest populations may return and continue to attack crops with no natural suppression. One of the most fundamental IPM practices is incorporating pests' natural enemies in the production process on the farm.

II.7 Conclusions

Agriculture is essential for the economy of Bangladesh and Integrated Pest Management is an important component of agricultural development. Chapter two identified the different pest management policies, programs and institutions involved with the dissemination of IPM in Bangladesh. The IPM training methods and the different IPM technologies and practices presented in this chapter are used for the cost-effective evaluation in the following chapters.

Chapter III: Methods

III.1 Introduction

Chapter three presents the methodology used to evaluate the cost-effectiveness of IPM diffusion methods in Bangladesh. The first section of this chapter explains how effectiveness of IPM dissemination methods is measured, while the second section examines the cost. The third section describes how the overall cost-effectiveness of the IPM training methods is calculated.

III.2 Measuring Effectiveness of IPM Training Methods

The objectives in chapter one outline the different criteria for evaluating effectiveness of IPM diffusion methods, and this chapter describes how these objectives will be addressed. The methods for measuring effectiveness of IPM diffusion programs described in this chapter include: measuring each method's ability to reach the greatest number of farmers within a given budget, spread information quickly, and influence the probability of adoption of IPM. Additional criteria for effective diffusion methods are the ability to influence the probability of appropriate use of IPM, influence retention of IPM over time, provide a level of knowledge so participants can adapt knowledge to various situations on the farm, and being accessible to farmers of limited resources. Once the individual measures of effectiveness are presented, the cost of the training methods is explained and a measure of overall cost-effectiveness is given.

III.2.1 Measuring Reach

Determining how many farmers each method reaches for a given budget requires information on the number of people who participate in the various types of training. Information on the number of attendees at each training session may be obtained from the institutions that sponsor IPM extension. Statistics on how many people are reached by mass media can be collected from the government, as well as television and radio stations. Data on the reach of field day demonstrations may be obtained from the IPM CRSP, the DAE and other institutions. Statistics on the number of farmers trained through FFS are given by CARE and the DAE.

III.2.2 Measuring Speed

Estimating the speed at which each method delivers information to farmers is based on information obtained about the different methods but is not based on formal quantitative analysis. If farmers do not receive information in a timely manner, the technology may lose its usefulness by the time it reaches them. If a dissemination method is too slow then the benefit of that technology is reduced because of the inefficiency of that method. In certain situations such as blight, if information is not spread rapidly it could have negative consequences that make finding a method that spreads information quickly is very important. Based on expert opinion we assume that mass media reaches farmers at the fastest rate of all formal methods. Other methods such as field day demonstrations and extension agent visits may not transfer information as quickly as mass media, but may be more effective at spreading information faster than FFS.

III.2.3 Measuring Adoption

One of the most important characteristics of an effective IPM training method is whether or not receiving information from that source plays a significant role in influencing farmers to adopt IPM. Rogers (1962) describes the process of adoption as "the mental process an individual passes from first hearing about an innovation to final adoption" (p.17, Feder et al. 1985). Researchers have developed numerous adoption models over the years in order to better understand farmers' adoption processes. The theoretical framework of most adoption studies assume that farmers will adopt an innovation if the expected net benefit of that innovation is greater than the net benefit of the current practice.

Qualitative Response (QR) models are often used to estimate the relative importance of various factors in influencing adoption. Adoption studies use QR models to measure whether or not a decision maker, with a given set of attributes, will make a particular choice. In a basic QR adoption model, the dependent variable *Y* takes on a value of one if the farmer adopts the technology or zero if the farmer does not adopt the innovation. When the dependent variable is binary, the model explains how various factors, captured in the model's independent variables, affect the probability of adoption.

A linear probability model is a type of QR model that uses Ordinary Least Squares (OLS) to estimate adoption. The probability of y = 1 is the same as the expected value of y in the linear probability model (Wooldridge, 2003). This linear equation, illustrated below, is called the response probability.

$$\mathbf{P(y = 1|x) = E(y|x) = B_0 + B_1X_1 + \ldots + B_kX_k}$$

Where *P* represents the probability of adoption and *B* represents the parameters that affect adoption for the independent variables represented by *X*. The shortcoming of the linear probability model is that "except in the case where the probability does not depend on any of the independent variables, heteroskedasticity is present in the model, rendering the T and F statistics invalid" (Wooldridge, 2003, p. 243). Another drawback of the linear probability model is that the model's predicted probability of adoption may fall outside the realistic range between zero and one. Furthermore the linear probability model assumes that *Y* is linearly related to the independent variables for their entire range of values and does not take into account the diminishing marginal effects as the independent variables increase (Maddala, 1983).

Using a limited dependent variable (LDV) that is restricted to having values between zero and one can overcome the limitations of linear probability models. The probit model is a type of QR model with a standard normal functional form that uses an LDV. The problem of heteroskedasticity is accounted for when using a probit model because it uses a maximum likelihood estimator that estimates the value of y given x (Woodridge, 2003). Given the advantages of a probit model, it should produce estimates that can be interpreted more appropriately than results generated from a linear probability model.

Numerous studies have utilized different forms of the probit model to measure adoption of agricultural technologies and practices. Isham (2002) uses a probit model to analyze the effects of social capital on fertilizer adoption in Tanzania. Halloway et al. (2002) use a spatial probit model to measure the effects on adoption of high yielding varieties of rice among Bangladesh farmers. Mbata (2001) uses a multivariate probit model to estimate the determinants of animal traction adoption in Lesotho.

A probit model is appropriate for measuring adoption in this study, however, a dichotomous probit model, with values between zero and one, is not ideal. Farmers have multiple technologies and practices extended to them and individuals may choose to adopt a wide variety of these IPM practices. For example, one farmer may have adopted the practice of reducing the number of times he sprays his rice, while another farmer may have reduced his number of rice sprays and also adopted pest resistant varieties of rice. It is not accurate to categorize both farmers as simply IPM adopters since the second farmer uses a greater degree of IPM than does the first farmer. Numerous IPM practices are examined in this study and farmers may adopt any number of these practices, therefore limiting the dependent variable to either zero or one is not appropriate in this adoption analysis.

A modified type of probit model known as the ordered probit is used in this study because it allows the dependent variable to take on a discrete number of integer values other than 0 and 1. The parameter estimates of the ordered probit model capture the different degrees of IPM adoption for simple, intermediate and complex IPM technologies and practices. The ordered probit model gets its name because in the model *Y* becomes an ordered rather then an arbitrary response (Wooldridge, 2002).

The parameter estimates for the ordered probit model give an accurate interpretation of whether or not the coefficients are positive or negative, however the marginal effects must be calculated in order to obtain results for the coefficients on the independent variables that can be easily interpreted. The marginal effect is the marginal change in the probability of observing success given a one unit change in the independent variable. The marginal effects for the ordered probit model are determined by the following equation.

$$\partial \mathbf{P_i} / \partial \mathbf{X_{ij}} = \boldsymbol{\beta_j}\ \mathbf{P_i}\ (\mathbf{1} - \mathbf{P_i})$$

where β_j is the parameter estimate for the independent variable j (Tjornhom, 1995).

Ordered probit models have been used in several agricultural adoption studies. For example, Baidu-Forson et al. (1997) rank eight different plant traits such as yield, perceptions and threshing. They use an ordered probit model to estimate farmers' utility from adopting plants with these different traits. Negatu and Parikh (1999) combine a probit and an ordered probit model to study the relationship between farmers' perception of a technology and the probability of its adoption. This study conducted in Ethiopia finds that perceptions such as a technology's effect of grain yield and marketability have significant influence on the probability of adoption.

The different values of *Y* in this study are quantified based on the number of technologies that a farmer adopts from the simple, intermediate, and complex categories. Five simple technologies, nine intermediate technologies and three complex technologies are used to quantify farmers' degree of IPM adoption. The technologies are listed in table 3.1.

TABLE 3.1
COMPLEXITY CATEGORIES OF IPM TECHNOLOGIES & PRACTICES

Simple Technologies & Practices 1. Resistant varieties of rice 2. Resistant varieties of vegetables 3. Sweeping pests off rice with hand nets 4. Placing branches for birds to perch in the rice fields 5. Hand picking insects off of cabbage
Intermediate Technologies & Practices 1. Hand weeding of cabbage 2. Clipping infected rice leaves 3. Sun solarization of rice beds 4. Sun solarization of vegetables beds 5. Sawdust burning in vegetable beds 6. Spreading poultry refuse on vegetable seed beds 7. Spreading mustard oilcake on vegetable seed beds 8. Setting mashed sweet gourd traps in gourd fields 9. Reducing spraying in rice
Complex Technologies & Practices 1. Grafting of eggplants 2. Using beneficial insects in rice 3. Using beneficial insects in vegetables

The present study estimates three different ordered probit adoption models, one for the five simple technologies, one for the nine intermediate technologies and one for the three complex technologies. The dependent variable takes on the value of the number of technologies that a farmer adopts for each of the different categories of complexity. This system of categorization allows for an accurate estimation of farmers' level of IPM adoption. The values of *Y* may be between (0,1,2,3,4,5) for simple technologies, (0,1,2,3,4,5,6,7,8,9) for intermediate technologies and (0,1,2,3) for complex technologies. The ordered probit adoption model used to measure adoption of IPM for individual farmer *i* in group *j* is expressed in equation (1).

$$(1) \quad \mathbf{Y_{ij} = \alpha_j X_i + \beta_j Z_i + \epsilon_{ij}}$$

where Y_{ij} represents the number of technologies in group j that the i^{th} farmer adopts. α_j and β_j represent the vector of parameters that affects the probability of adoption while, X_i and Z_i represents the vector of explanatory variables. X represents the explanatory variables for different methods, such as mass media, field days, and farmer field schools, from which farmers may obtain IPM information and Z represents the socio-economic factors that effect adoption such as, age, income and number of family members. ϵ represents the unexplained factors that affect the probability of adoption. The different groups represented by j in the model are assigned depending on the type of IPM technologies that are being evaluated. j_1 represents the group for simple technologies and practices, j_2 represents the group for intermediate technologies and practices, and j_3 represents the group for complex technologies and practices.

The independent variables represented by X and Z that influence the probability of adoption are identical in the analysis for all three complexity types of IPM technologies and practices. The independent variables, represented by X in the adoption equation, that describe the types of training methods where farmers obtain information about IPM technologies and practices, are listed in Table 3.2. The table includes formal diffusion methods such as mass media, field days, agent visits and FFS. All independent variables listed in table 3.2 are binary.

TABLE 3.2
VARIABLES REPRESENTING IPM TRAINING METHODS

FORMAL TRAINING METHODS	
Variable Name	**Method**
(MMEDIA)	The farmer has received information about IPM through mass media.
(FDAY)	The farmer has attended a field day demonstration conducted by either BARI/DFID or the IPM CRSP.
(VISIT)	The farmer has received a visit by a DAE extension agent or from the IPM CRSP.
(FFS)	The farmer attended a farmer field school run by the DAE or CARE.

A Farmer's decision to adopt a practice is not only influenced by where he or she received the information but also by a variety of socio-economic factors. These socio-economic factors represented by Z in the equation above include farm size, age and family members. The model includes fifteen socio-economic variables, five of which are continuous and ten are binary. The socio-economic variables, represented by Z, are presented and explained in Table 3.3.

TABLE 3.3
SOCIO-ECONOMIC FACTORS INFLUENCING IPM ADOPTION

Variable Name	Method
(AGE)	Continuous: Farm's age in years.
(AGESQ)	Continuous: The farmer's age squared.
(FAM)	Continuous: Number of family members.
(SIZE)	Continuous: Size of the farm in decimals (100 decimals = 1 acre).
(MARK)	Continuous: Distance from the farm to the nearest market (in km).
(ORG)	Binary: 1 if farmer is involved in a community organization. 0 otherwise
(MALE)	Binary: 1 if farmer is male 0 if farmer is female
(PRIM)	Binary: 1 if the farmer has completed Primary education 0 otherwise
(HSSC)	Binary: 1 if the farmer has completed intermediate education 0 otherwise
(DEG)	Binary: 1 if the farmer has completed his or her degree 0 otherwise
(GAZIPUR)	Binary: 1 if the farmer lives in Gazipur 0 otherwise
(JESSORE)	Binary: 1 if the farmer lives in Jessore 0 otherwise
(COMILLA)	Binary: 1 if the farmer lives in Comilla 0 otherwise
(NILPHAMARI)	Binary: 1 if the farmer lives in Nilphamari 0 otherwise
(THAKURGION)	Binary: 1 if the farmer lives in Thakurgion 0 otherwise

Endogeneity

The adoption model must also address the potential issue of endogeneity. In the adoption model above, an independent variable, such as the one representing FFS participants is a choice variable and it may be correlated in some way with the unobservable variables in the model (Millimet, 2001). Godtland et al. (2004) explains that there are differences between FFS farmers and other farmers that make it difficult to compare the two groups. FFS farmers may voluntarily choose to participate in the FFS training because they possess unobservable characteristics such as being more innovative and productive. Factors such as productivity and innovativeness can not be observed in the regression model and are correlated with FFS participation but also impact farmers' level of IPM adoption. Feder et al. (2004A) and Feder et al. (2004B) also address the issue of FFS participants not being randomly selected and causing biased estimates when FFS participants are compared with non participants. The endogeneity issue should be examined in this study in order to obtain accurate estimates for the factors influencing adoption of IPM.

The first step in correcting for the endogeneity problem is creating a model that predicts FFS participation. The binary probit model for FFS participation is presented in equation (2).

$$\textbf{(2)} \quad \mathbf{P_i = \eta X_i + \epsilon_i}$$

Where P_i represents the probability that the ith farmer attends FFS and η_i represents the vector of parameters that affect the probability of FFS participation. X_i represents the vector of explanatory variables that affect the probability of FFS participation, which are the same variables presented in Table 3.3. ϵ_i represents the unexplained factors that explain participation in FFS for the i^{th} individual.

Once the probit model for FFS participation has been estimated, the predicted values for FFS participants can be obtained. The predicted values for FFS then replace the binary FFS variable in the ordered probit model, explained in equation (1), estimating the factors influencing adoption. The factors influencing adoption scores should also be estimated using the sub-sample of farmers who have attended FFS. Using the predicted values for FFS to replace the binary variable representing FFS participation in the ordered probit adoption model shows the effect that FFS training has on adoption while controlling for the other unexplained factors affecting FFS participation but also influencing adoption (Millimet, 2001).

III.2.4 Measuring Appropriate Use

Another component of effectiveness is whether or not IPM training methods teach farmers to use IPM practices appropriately. The study uses a two step procedure to measure appropriate use. The first step is to test which factors influence farmers to adopt a specific practice or technology. This model is similar to the ordered probit model in the previous section except that in this adoption model the dependent variable is dichotomous, taking on a zero or one value, because it represents adoption for only one technology or practice. Variables used in this model are the same ones presented in tables 3.2 and 3.3. The dichotomous probit model for the factors influencing individual farmer *i* in group *j* to adopt a specific practice is presented in equation (3).

$$(3) \quad \psi_{ij} = \sigma_j X_i + \upsilon_j Z_i + \epsilon_i$$

Where ψ_{ij} is 0 or 1 depending on whether farmer *i* in group *j* adopts a specific IPM technology. σ_j and υ_j represent the vector of parameters that affect the probability of adoption while, X_i and N_i represents the vectors of explanatory variables. X_i represents the explanatory variables for different methods from which farmers may obtain information about IPM and Z_i represents the socio-economic factors that effect adoption. *X* and *Z* represent the same variables as those presented in Tables 3.2 and 3.3 respectively. The variable ϵ_i represents the unexplained factors that affect the probability of adoption for individual *i*. The different groups represented by *j* in the model are assigned depending on the IPM technology that is being evaluated. J_1 represents the group for a simple technology or practice, and j_2 represents the group for a more complex technology or practice.

One of the difficulties in measuring appropriate use is the potential for selection bias to exist in the model. In this model the decision and ability of a farmer to use a particular practice appropriately may be based on the fact that certain farmers are selected into the training program and of those farmers in the program, only a certain number of those use the practices appropriately. Appropriate use is there for only observed for a selected non random sample of the population (Millimet, 2001).

In order to eliminate the potential selection bias problem in the model, Heckman (1979) proposes calculating the inverse mills ratio which is a monotonically decreasing function representing the probability that an observation is selected into the sample. The second step in measuring appropriate use of IPM practices entails calculating the inverse mills ratio. The inverse mills ratio calculated for individual *i* in group *j* is explained in equation (4).

$$\textbf{(4)} \qquad \lambda_{ij} = \frac{\phi(\Gamma_i)}{1 - \Phi(\Gamma_i)}$$

Where λ_i is the inverse mills ratio, ϕ represents the normal density and Φ represents the cumulative density of variable Γ for the i^{th} individual (STATA, 2003). Once the mills ratio has been calculated, the model for appropriate use may be estimated. This model is also a binomial probit model with one representing those farmers who use the technology appropriately, and zero representing those who do not. The model for appropriate use is expressed in equation (5).

$$\textbf{(5)} \qquad V_{ij} = \varsigma_j \lambda_i + \rho_j X_i + \tau_j Z_i + \gamma_j I_i + \epsilon_i$$

The dependant variable V_i is 0 or 1 depending on whether farmer *i* in group *j* uses the IPM practice appropriately. ς_i, ρ_j, τ_i, and γ_j represent the vector of parameters to be estimated. λ_i represents the variable for the inverse mills ratio for individual *i*. Should the variable for the mills ratio be significant in the regression equation, it would indicate that appropriate use of the IPM technology is affected by selection bias. The vector X_i represents the dummy variables for the different methods from which farmers may obtain information about the technology. Z_i represents the socio-economic factors that effect appropriate use. *X* and *Z* represent the same variables presented in tables 3.2 and 3.3 respectively. I_i represents how long ago the i^{th} farmer learned about the technology. The variable ϵ_i represents the unexplained factors that affect the probability of appropriate use. J_1 represents the group for a simple technology or practice, and group j_2 represents the group for a more complex technology or practice.

III.2.5 Measuring Retention

Farmers' ability to use technologies and practices appropriately is related to their being able to retain knowledge and information about those practices over time. Rola et. al (2005) compare retention rates between FFS graduates who were trained prior to 1995 with FFS graduates trained more recently. The study finds no significant difference in knowledge scores between the group of farmers trained by FFS before 1995 and the group trained more recently. This result indicates that FFS graduates retain acquired knowledge overtime. Retention of appropriate use of IPM is measured in this study by first examining the descriptive statistics to see how many years ago the appropriate users received their information and from what sources.

Retention is measured econometrically in this study by including the variable I_i in the appropriate use model in the previous sub-section to represent the time when farmer *i* learned about the technology. The time variable in the regression model compares the likelihood of appropriate use for farmers who learned about a particular technology during a certain period of time with those who heard about the technology during a different period of time. If the variable representing time shows significance in the regression results, this would indicate that there may be a difference in retention between farmers who learn about technology during these different time periods.

III.2.6 Measuring Adaptability of Knowledge

Another component of effectiveness is whether farmers who attend IPM trainings learn particular skills that can be adapted to other areas of their farm. Adaptability of knowledge is estimated using a dichotomous probit model where the dependent variable takes on a value of one if the farmer has developed an IPM practice through his or her own experience and experimentation or a zero if he or she has not. The study assumes that those farmers who have developed IPM practices on their own possess a level of understanding about IPM that they have been able to adapt to different situations on their farm. The ability of farmer *i* in group *j* to transfer knowledge from one situation to another on his or her farm is estimated in equation (6).

$$(6) \quad \mathbf{y_i = \upsilon X_i + \varphi Z_i + \epsilon_i}$$

Where Y_i represents the probability that a farmer *i* has developed an IPM practice through his or her own experimentation. υ and φ represent the vector of parameters that affects the probability of discovery through experimentation and X_i and Z_i represents the vector of explanatory variables. X_i represents the explanatory variables for different methods from which farmers may obtain information about the technology and Z_i represents the socio-economic factors that effect the probability of discovery through experimentation. X and Z represent the same variables presented in tables 3.2 and 3.3 respectively. The variable ϵ_i represents the unexplained factors that affect the probability of discovery through experimentation. This model presents insight into which training methods and socio-economic factors influence farmers to develop IPM practice through experimentation and provides them with the ability to adapt and transfer knowledge to various situations on the farm.

III.2.7 Measuring Accessibility to Limited Resource Farmers

Examining whether or not IPM methods are open and available to farmers of limited resources with small land holdings is another component of effectiveness. In Bangladesh farmers are classified as *landless* if they have less than .5 acres, *marginal* if they maintain between 1.49 acres, *small* if they cultivate between 1.5 and 2.5 acres, *medium* if they farm between 2.5 and 7.5 acres and *large* if they own more than 7.5 acres (Ministry of Agriculture, 2003C). Accessibility is measured in this study by evaluating the percentage of respondents in each farm size income group who have been to the various training programs, and by the percentage of people in the different income groups who are participants in the training methods.

III.2.8 Measuring Informal Diffusion of IPM

Evaluating informal diffusion of IPM is related to the number of farmers that a training method reaches within a given budget. Rola et. al (2002) and Feder et. al (2004B) both find no evidence to suggest that informal diffusion occurs at a greater rate in FFS villages than in non-FFS villages. If an IPM training method such as FFS does not promote the secondary spread of knowledge from participants to other non-participants in the village then its effectiveness is limited. The program may be financially unsustainable and it may be difficult to implement it at a national level (Feder et. al, 2004B). This study first addresses informal diffusion by conducting a T-test measuring the difference between farmers in FFS villages and non-FFS villages in the number of times in the survey the respondents mention hearing about IPM practices or technology from informal sources such as neighbors and relatives. Analyzing this difference provides further understanding as to how FFS influences the informal secondary spread of information in communities.

Regression analysis provides additional information and allows for stronger conclusions to be drawn about informal diffusion than conducting only a T-test. The model used in this analysis breaks the respondents in the sample into groups similar to the groups defined by Feder et al. (2004B). Respondents who attend FFS are represented by the variable TRAINED; respondents who live in the village with FFS but did not attend FFS are represented by the Variable EXPOSED, and Respondents who live in other villages are the control group. Some of the farmers in the control villages have been trained on IPM through other less intense methods such as field days and agent visits. The study uses four ordered probit regression models, one for simple, one for intermediate, one for complex practices and technologies and one for all of the technologies combined together that are mentioned in the survey. The model used in this analysis is described in equation 7.

$$(7) \quad \mathbf{Y_{ij} = \eta_j N_i + \gamma_j Z_i + \epsilon_i}$$

Where Y_{ij} represents the number of IPM practices that the ith farmer in group j has heard about. The dependent variable takes on a discrete number of values for the number of IPM practices to which a farmer has been exposed. η_j and γ_j represent the vectors of parameters that may affect the probability of farmer exposure to different practices. N_i represents different classifications, such as TRAINED and EXPOSED for the ith farmer. Z_i represents the socio-economic factors that affect knowledge of IPM technologies. Z_i represents the same variables presented in Table 3.3. ϵ_i represents the unexplained factors that affect knowledge of IPM practices. J_1 represents the group for simple technologies, J_2 represents the group for intermediate technologies, J_3 represents the group for complex technologies and J_4 represents the group for the entire set of IPM technologies.

This model can determine whether or not farmers who have been to FFS have been exposed to more practices than other farmers. It can evaluate whether or not exposed farmers in the FFS village who did not attend FFS have heard about more practices than farmers in the control villages that have had no FFS program, but may have learned about IPM from a field day, agent visit or another farmer. If informal diffusion of IPM information is occurring in FFS villages then the exposed farmers in the FFS village should be aware of a significantly greater number of IPM practices than farmers in the control villages (Feder et. al, 2004B). Furthermore by classifying the practices by their complexity level the study can measure whether informal diffusion is greater for simple practices than it is for more complex practices.

III.3 Measuring Costs of IPM Training Methods

The second component of cost-effectiveness is calculating the cost of administering each IPM training method. Several different cost criteria are evaluated in this study such as the costs to the institutions that administer the training and the costs to the farmers who participate in training sessions. Many costs are incurred when IPM training programs are conducted. Incorporating the different costs into the analysis helps determine the accurate expense of IPM diffusion methods.

Accurately measuring the cost of IPM training methods requires recognizing the fixed and variable costs along with the average and marginal costs of these programs. Fixed costs are incurred by the institutions that run the various training programs and do not increase when additional training is held or when more farmers participate in the training. Variable costs are the costs that increase when more training programs are held or when more farmers attend. The average cost of each method is the total cost of administering the training method divided by the number of farmers who participate in the training. Marginal cost is the cost of providing an additional training session or allowing an additional farmer to participate in the training. Each of these types of cost provides a different aspect in the true cost of administering the IPM training methods.

Mass media methods such as bulletins or the radio cost relatively little to administer. A radio broadcast has essentially no variable cost because once the message has been transmitted there is little to no cost to have people receive the information. Similarly, the average cost for conducting a radio broadcast is relatively low when the costs are divided by the number of farmers reached but the marginal cost of reaching an additional farmer with the radio broadcast is negligible. Variable costs for printing a bulletin include print material include the ink and the paper used to create the bulletins. The average cost for print media is low, and the marginal cost for print media is also minimal.

Fixed costs for a field day demonstration include presentation stage, banners, and the opportunity cost of the training agents' time. Food for participants, materials for the training, and transportation costs are all variable costs for field day demonstrations. The average cost for field days is low due to the large number of people that are able to attend. The marginal costs for field days would also be very low and might only consist of extra food, materials, and security for the additional participants.

Extension agent visits have fixed costs such as the agent's salary and the opportunity cost of his or her time. Other fixed costs include maintaining the national extension system and training the agents about IPM. The variable cost for agent visits is low. Since agents' salaries are fixed any visits the agent conducts has a low variable cost that includes food and transportation expenses. Despite the low variable cost there is a limit to the number of visits that an individual agent can realistically be expected to make. The average cost for an agent visit depends on the number of farmers that the agent is able to visit, but the marginal cost is low as each additional visit would have a low cost, up to a certain number of visits. Agents are also able to extend information other than on just IPM to farmers, so their cost of extending IPM information to farmers is lower than the full cost of their visit.

The fixed costs for the FFS include administering the national level program such as paying consultants and administrators' salaries and conducing research on the field school program. Materials, food, and renting locations in the villages for the training are all variable costs associated with FFS. The FFS facilitators' salaries are also considered variable because, unlike an extension agent, FFS facilitators are paid a wage for each FFS session they conduct. There is also an opportunity cost of the facilitators' time because these government agents are also paid a salary in addition to their stipend for conducting FFS. If the facilitators are not engaged in FFS, they could presumably be undertaking another productive activity. Studies conducted around the world found that the average cost of the FFS program is very high. Quizon et al. (2004) found that the average cost of an FFS in the Philippines is US $47.60 and US $62.00

in Indonesia. The marginal cost of the farmer field schools are also high because the FFS curriculum is designed to train no more than 25 farmers at a time.

Farmers who participate in IPM training also incur costs. Costs to farmers for participating in the training can be measured in the fees they may have to pay in order to attend or in the opportunity cost of their time spent in the training. Methods with lower monetary fees and smaller opportunity cost are more appealing to farmers but farmers may be willing to incur greater costs if the potential benefits of the training are higher.

Many different costs must be considered when calculating the expenses of running IPM training programs. The formal analysis used to create a measurement of cost-effectiveness incorporates the variable field costs of running the training programs, the opportunity costs of the trainers' time and the opportunity cost to the farmers who participate in the training programs. Field costs include the cost of running an FFS or a field day in a villages or maintaining an extension agent in a particular place. The study presents the available sunk and fixed cost information, such as the administration of national FFS IPM program and maintaining a central extension office in the Capital Dhaka. It was not possible to obtain all of the fixed cost information for these programs. The fixed costs are treated as sunk and are not specifically included in the overall calculation of cost-effectiveness of IPM diffusion methods.

III.4 Measuring Overall Cost-Effectiveness of IPM Training Methods

Once the effectiveness and cost components of IPM diffusion have been evaluated, a model that estimates overall cost-effectiveness of IPM training methods may be created. The criteria from the effectiveness section that are included in the overall cost-effectiveness analysis are the method's ability to reach the greatest number of farmers with in a given budget, the method's ability to influence farmers to adopt IPM practices and the methods ability to influence farmers to use the practices appropriately. The cost components that are incorporated in the cost-effectiveness estimate are the variable field cost of using the training methods, along with the opportunity cost of the trainers' and the participant farmers' time. Cost-effectiveness is then calculated by creating an estimate for the benefits of adopting and using a specific IPM technology or practice appropriately. Using an IPM technology or practice appropriately affords the farmer some per acre benefit B_a in the form of increased profit per acre. The benefit per acre may be obtained by equation (7):

$$(7) \quad \mathbf{B_a = \{(Q_n - Q_o) * P\} - \{(C_n - C_o)\}}$$

Q_n represents the quantity produced in tons per acre of the crop for which the new IPM practice is applied, while Q_o represents the quantity produced in tons per acre of the crop for which with the farmers' original practice is applied. P is the price per ton of a particular crop. C_n is the cost per acre of applying the new IPM practice while C_o is the cost per acre of the old practice. The benefit per acre of adopting and using a new IPM practice appropriately is calculated with this equation.

Once the benefit per acre of a new IPM practice has been estimated it is possible to calculate the benefit per farmer for the new technology. The benefit per farmer is estimated by multiplying the per acre benefit by the estimated amount of land the average farmer in Bangladesh has devoted to the particular crop for which the IPM technology is applied.

When the benefit per farmer of the IPM practice has been calculated the benefit of extending that practice through different methods may be determined. The benefit per method is determined by calculating the percentage of farmers exposed to the practice by a particular method who adopt and who use it appropriately. The study assumes that those farmers who use the practice appropriately receive the full benefit of that technology while those who adopt but do not use it appropriately receive no benefit, while cost of extending that practice to them is still incurred. The percentage of farmers who use the practice appropriately is multiplied by the benefit per farmer of that practice to calculate the per farmer gross benefit of extending that practice through a particular method. The gross benefit per farmer of extending a particular practice is calculated by multiplying the per acre benefit of the technology by the amount of land the average farmer has under cultivation of a particular crop. Once the monetary benefit per farmer trained on a certain IPM practice through a particular method has been calculated the dollar benefit is subtracted from the cost of administering that method to obtain a net benefit of a technology extended by a particular method.

CHAPTER IV: RESULTS

IV.1 Introduction

The results of the cost-effectiveness assessment for IPM training methods in Bangladesh are presented here in chapter four. The sample's descriptive statistics are presented in the first section of this chapter, while the second section gives the results of measuring effectiveness. The cost components in the analysis are presented in the third section, while the overall measurement of cost-effectiveness is presented in the fourth section.

IV.2 Descriptive Statistics

The study used a survey instrument to obtain information from farmers in Bangladesh. The results of the survey were used to provide data for estimating the effectiveness component of the study. The survey methodology was developed in collaboration with the researchers at Virginia Tech and the scientists working on the IPM CRSP in Bangladesh. The survey was translated from English to Bengali and field tested before being administered to farmers in various regions of Bangladesh. Design of the survey began in May of 2004 and the data collection took place in July and August of that year (See survey in Appendix A).

Data were collected from 350 farmers in four different geographic regions of Bangladesh. These regions (called districts in Bangladesh) include Jessore in the western part of the country, Comilla in eastern Bangladesh, Gazipur in the center of the country and Nilphamari and Thakurgion in the north (See Map of Bangladesh). The number of respondents that were interviewed in the different regions of Bangladesh is listed in Table 4.1. The two Northern Districts of Nilphamari and Thakurgion are very close in proximity so in some of the econometric analyses these two districts are combined into one variable called Northern.

Table 4.1
Number of Respondents from Different Regions (Districts) of Bangladesh

District	Number of Respondents
Gazipur	102
Jessore	107
Comilla	84
Nilphamari	10
Thakurgion	47

A team of enumerators along with the project leaders traveled to the various districts to administer the survey. Villages were selected for the sample based on the type of IPM trainings that had previously been conducted. The team worked with the local extension personnel in each village to find a representative sample of farmers, some of whom had been trained on IPM through various methods and others who had not. The enumerators asked farmers what IPM training they received and about their knowledge of different technologies and practices. Participants were interviewed individually and each interview lasted between half an hour and forty-five minutes. This sample was not collected to measure adoption rates of IPM technologies, rather it was administered in order to see how effectively different training methods diffuse IPM information to farmers. For this reason a certain part of the sample was not chosen randomly but was selected because those farmers had participated in one or more types of IPM training methods.

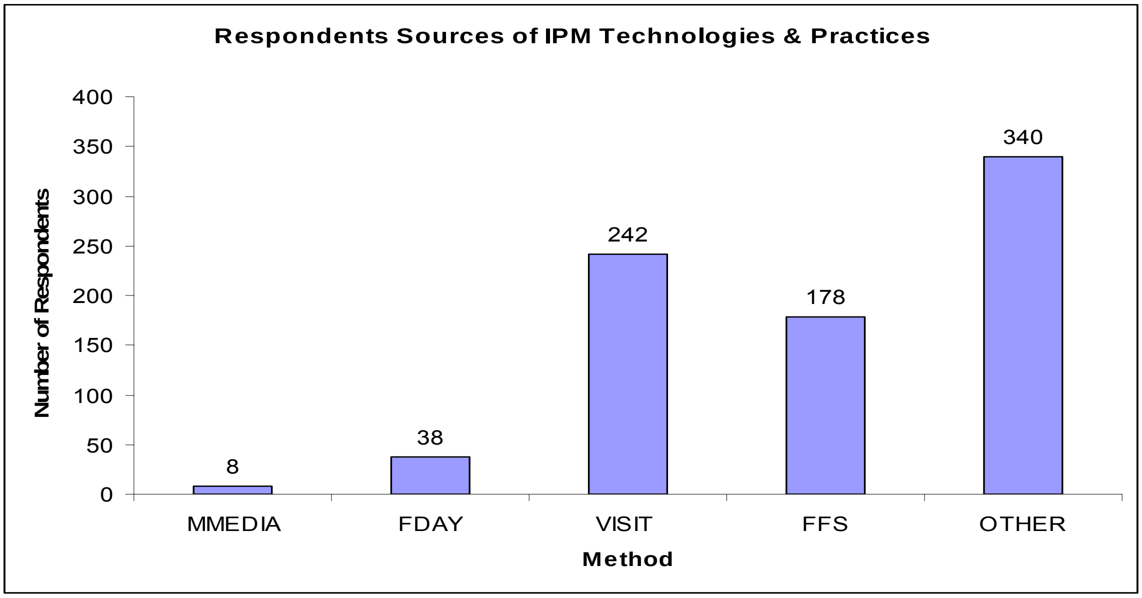
Table 4.2 presents the descriptive statistics for the sample which represents a large cross-section of farmers in Bangladesh. Ages in the sample vary greatly, as do number of years of experience. The majority of the farmers are men as they are generally the ones who make the decisions related to pesticide use. Twenty-four percent of the respondents have primary levels of education while 38% have an intermediate level of education. Twenty three percent of the sample is illiterate or has no education while 15% have earned their high school degree. The majority of farmers, 61%, are involved in some sort of community organization. Farm size ranges from miniscule to very large by Bangladesh standards.

Table 4.2
Description of Socio-Economic Variables in the Study

VARIABLE	DESCRIPTION	OBS.	MEAN	STD. DEV.	MIN	MAX
AGE	in years	350	37.46	12.65	14	89
AGESQ	years squared	350	1,563.06	1,067.62	196	7,921
FAM	# of family members	350	6.28	2.62	2	16
MALE	1 if male	350	0.93	0.25	0	1
PRIM	1 if primary education	350	0.24	0.43	0	1
HSSC	1 if intermediate education	350	0.38	0.64	0	6
DEG	1 if received degree	350	0.15	0.36	0	1
ORG	1 if belongs to organization	350	0.61	0.49	0	1
FARMSIZE	in decimals (100 dec. = 1 acre)	350	254.29	314.53	1	3,160
MARK	km from market	350	1.60	1.19	0.25	7

Farmers in the sample mention hearing about IPM from numerous sources, including the marketplace, pesticide dealers and numerous small NGOs. In order to create an effective analysis and generate clear and meaningful results the study focuses on the major formal extension methods, such as mass media, field days, agent visits and FFS. Results from the sample indicate that most farmers interviewed in the survey have received information about IPM technologies and practices from several different sources. Respondents' sources for IPM are presented in Figure 4.1. One of the first conclusions that can be drawn from figure 4.1 is that very few farmers have received information about IPM technologies and Practices from the mass media. A fairly small number, 38 claimed to have received information about IPM technologies and practices from field day demonstrations conducted by either BARI/DFID or the IPM CRSP. CARE and DAE FFS have trained 178 farmers in survey. The largest formal source for respondents in the survey to have received IPM information is visits by DAE extension personnel or the IPM CRSP. Nearly all farmers in the sample, 340 out of 350 respondents, mentioned hearing about some IPM practice or technology from a source labeled as other. These other sources include informal methods such as neighbors and relatives or other less influential formal methods such as IPM clubs. The number of sources mentioned in figure 4.1 totals more than the 350 respondents in the sample because nearly all farmers stated that they have received IPM information from more than one source.

Figure 4.1



IV.3 Effectiveness Results for IPM Training Methods

Results for the effectiveness criteria from the objectives in Chapter one are presented in this section. The seven evaluation criteria for assessing effectiveness of IPM diffusion methods include each method's ability to reach a large number of farmers within a given budget, spread information quickly, influence farmers to adopt IPM, and train farmers to use IPM practices appropriately. Additional components of effective include influencing farmers to retain information over time, providing enough knowledge so participants can adapt knowledge to different practices on the farm, being accessible to limited resource farmers. The results from the effectiveness analysis are used along with the cost results to create a framework for modeling overall cost-effectiveness of IPM dissemination methods in Bangladesh.

IV.3.1 Results for Reaching Farmers

The numbers provided in figure 4.1 in the previous section explain where farmers in the sample have obtained IPM information. However, in order to understand which methods reach the greatest number of farmers for a given budget, information must be used from the institutions that sponsor IPM. Although newspaper articles, television programs and radio broadcast are being used in Bangladesh to present topics related to agriculture, the study found no indication that any sponsoring institutions are using much electronic media to extend IPM information to farmers. Several field day demonstrations have been conducted by BARI/DFID in the Jessore and Comilla districts of Bangladesh, while the IPM CRSP has also conducted field days Jessore. The field days generally attract between 200-400 participants. The DAE also states that they conduct field days for 250 farmers in every village where an FFS is held.

Every union in Bangladesh, a cluster of two or three villages, has an extension agent known as a block supervisor who is an employee of the department of agricultural extension. These agents live in the village and visit and help farmers with a variety of farm issues in addition to IPM. According to the ministry of agriculture, the budget for the DAE was around ₤44 million in 2003, equivalent to over US $70 million. In 2003, Bangladesh employed 10,280 field level block supervisors and was looking to increase the field level staff to 12,640 (Ministry of Agriculture, 2003C). There were approximately 18 million farm households in Bangladesh in 2003, meaning that there was roughly 1 extension agent for every 1,750 farm households. The IPM CRSP also conducts farm visits and extends IPM information to farmers in the Gazipur, Jessore and Comilla districts. The budget for the IPM CRSP is slightly less than US $100,000 per year in Bangladesh. Less than US $30,000 goes to run the office at BARI and most of that money goes to research.

Both the DAE and CARE have incorporated farmer field schools as their principal diffusion method. The DAE FFS program is administered throughout the country while CARE's FFS program focuses in the northern part of Bangladesh. CARE has reached 221,375 people with their program, while the DAE is mandated to train 117,000 rice farmers and 78,000 vegetable farmers by 2006. By 2014 the DAE has been commissioned to train 1,720,000 farmers or around 20% of the pesticide using households in Bangladesh by FFS. The cost of this program is projected to be US $46.5 million between 2004 and 2014. The sheer size and commitment by the sponsoring institutions to FFS enables this method to train many farmers throughout Bangladesh.

The information obtained from the sponsoring institutions indicates that while the DAE's block supervisor agent visits are the largest method for diffusing general agricultural information to farmers in Bangladesh, farmer field schools are the most widely used method to extend IPM practices and technologies to farmers. Field days are less commonly used than are FFS and visits, while mass media is the least commonly used formal method for diffusing IPM to farmers in Bangladesh. The results in this section speak to the current state of IPM diffusion in Bangladesh rather than to the potential of certain methods, such as mass media, to reach the greatest number of farmers.

IV.3.2 Results for Spreading Information Quickly

Determining the rate at which different methods diffuse information to farmers is a value judgment based on what is known about them. Methods that bring information to farmers quickly allow farmers to receive the benefit of that information for a longer period of time. In certain situations such as blight, if information is not spread rapidly it could have very negative consequences that make finding a rapid dissemination method very important. The methods are ranked in terms of their effectiveness at quickly spreading information in Table 4.3. The methods are ranked from one to four, with one being the fastest and four being the slowest.

Table 4.3
Speed Rankings for IPM Diffusion Methods

Method
1. Mass Media
2. Field Day
3. Agent Visit
4. FFS

Mass Media has the greatest potential of all formal methods to reach farmers quickly as radio and television broadcasts can spread information over a great distance in a very short time. Field days are another way information can be disseminated to a large number of farmers however they do not function as quickly as mass media, because it takes time to organize and inform farmers about the occurrence of a field day.

Extension agents visiting farmers is another fairly fast method for diffusing information. The agents are normally in or around a particular area and if information needs to be spread quickly then agent’s can easily meet with farmers. Agents may need to be trained on the new information so the training process slows down the speed of this method. It would be quicker to establish a field day and bring in experts then it would be to train extension agents on the new problem. Farmer field schools are probably the slowest method of spreading information. FFS require time to establish and administer making them a less than desirable method for bringing information quickly. If information needs to be dispersed among a population in an emergency situation, the FFS model would be the wrong method to accomplish this task.

IV.3.3 Results for Influencing Adoption of IPM

This sub-section describes the effectiveness of different IPM dissemination methods on influencing farmers to adopt IPM technologies and practices. The results of the ordered probit models for simple, intermediate, and complex IPM practices are presented in Tables 4.4, 4.5, and 4.6. The results explain which factors influence the probability of adoption and provide insight into farmers' adoption decision making process for IPM. When interpreting the results for the ordered probit model, the coefficients for the variables can not be interpreted directly however the positive and negative signs on the coefficients indicate whether the variables have positive or negative influence on the probability of adoption. Computing the marginal effects allows interpretable coefficients for the variables in the model to be obtained. Results of the marginal effects for the three ordered probit models are presented in Appendix B.

The results of the adoption analysis for simple technologies are displayed in Table 4.4. The variables for all of the formal methods have positive coefficients indicating positive impacts on the probability of influencing adoption of simple IPM technologies and practices. The variable for the more intense FFS method is significant at the 1% level while the variable for the moderately intense VISIT is significant at the only the 10% level. The variables MMEDIA and FDAY are not statistically significant.

Table 4.4
Ordered Probit Results for Adoption of Simple Technologies & Practices

Ordered probit estimates		Number of obs	=	350	
		LR chi2(18)	=	162.49	
		Prob > chi2	=	0.0000	
Log likelihood = -492.55908		Pseudo R2	=	0.1416	

SIMPLESCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MMEDIA	0.008	0.385	0.983	-0.747	0.764
FDAY	0.114	0.197	0.562	-0.271	0.500
VISIT	0.219*	0.127	0.084	-0.029	0.467
FFS	1.122***	0.134	0.000	0.860	1.384
AGE	0.041*	0.023	0.077	-0.004	0.086
AGESQ	0.000*	0.000	0.084	-0.001	0.000
FAM	0.028	0.024	0.254	-0.020	0.076
MALE	-0.216	0.242	0.371	-0.691	0.258
PRIM	0.091	0.150	0.544	-0.203	0.384
HSSC	0.207*	0.106	0.051	-0.001	0.415
DEG	0.020	0.176	0.909	-0.325	0.365
ORG	0.447***	0.126	0.000	0.200	0.695
FARMSIZE	0.000*	0.000	0.074	-0.001	0.000
MARK	0.020	0.050	0.692	-0.078	0.117
JESSORE	-0.384**	0.156	0.014	-0.689	-0.079
COMILLA	0.369**	0.178	0.038	0.021	0.718
NILPHAMARI	0.071	0.365	0.846	-0.645	0.788
THAKURGION	-0.445**	0.201	0.027	-0.838	-0.051
_cut1	-0.495	0.552		(Ancillary	parameters)
_cut2	0.882	0.544			
_cut3	1.709	0.550			
_cut4	2.681	0.556			
_cut5	3.625	0.566			

Single, double, and triple asterisks indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

The significant socio-economic variables in the regression include AGE, which is positively associated with adoption and AGESQ which is negatively associated with adoption. Both are significant at the 10% level. The coefficient on the variable HSSC, intermediate levels of education, is positive and is significant at the 10% level. The variable representing membership in an organization, ORG, is significant at the 1% level and is positively correlated with adoption. Significance of the ORG variable indicates that farmers involved in the community are more likely to receive information about IPM and thus there is a higher probability that they adopt than those farmers who are not involved in the community. The different regions in the study are also significantly different from Gazipur in terms of their effects on adoption. Farmers in Jessore and Thakurgion are significantly less likely to adopt simple technologies than those in Gazipur while farmers in Comilla are significantly more likely to adopt than farmers in Gazipur. The significant difference between regions indicates that for a variety or reasons, including accessibility and resources, farmers have adopted more practices in certain districts than in others.

The marginal effects of the ordered probit for simple IPM technologies, listed in appendix B, allow for the coefficients of the independent variables to be interpreted for the different values of the dependent variable. The marginal effects are calculated for the different integer values of the dependent variable ranging from 0 to 5, which represent the number of simple technologies that a farmer may have adopted (STATA Reference, 2003). The results of the marginal effects demonstrate that participants of the more intense FFS training are more likely to adopt a high number of simple IPM technologies than those who did not participate in FFS. When the dependent variable, SIMPLESCORE, is equal to five, meaning that the respondent has adopted all five simple IPM practices, The FFS variable is significant at the 1% level with a coefficient of .08, indicating that FFS participants are 8% more likely to adopt all five simple technologies than those who did not attend FFS. The VISIT variable is significant at the 10% level, and both the FDAY and MMEDIA variables are not statistically significant.

Regression results for the adoption of intermediate technologies are displayed in Table 4.5. The less intense field day method, the moderately intense agent visit method, and the more intense FFS method all have positive coefficients, indicating positive impacts on influencing the probability of adoption for intermediate IPM technologies and practices. The VISIT variable is significant at the 5% level while the FDAY and the FFS variable are both significant at the 1% level. The coefficient of the MMEDIA variable is negative but it is not statistically significant.

Table 4.5
Ordered Probit Results for Adoption of Intermediate Technologies & Practices

Ordered probit estimates				Number of obs	= 350
				LR chi2(18)	= 91.43
				Prob > chi2	= 0.0000
Log likelihood = -621.56493				Pseudo R2	= 0.0685

INTERMEDIATE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MMEDIA	-0.223	0.374	0.550	-0.957	0.510
FDAY	0.549***	0.190	0.004	0.178	0.921
VISIT	0.315**	0.124	0.011	0.071	0.558
FFS	0.771***	0.127	0.000	0.522	1.020
AGE	-0.020	0.023	0.381	-0.064	0.024
AGESQ	0.000	0.000	0.255	0.000	0.001
FAM	0.013	0.024	0.583	-0.034	0.060
MALE	0.010	0.237	0.966	-0.454	0.474
PRIM	0.229	0.146	0.115	-0.056	0.514
HSSC	0.088	0.099	0.375	-0.107	0.283
DEG	0.142	0.170	0.405	-0.192	0.476
ORG	0.390***	0.123	0.002	0.149	0.631
FARMSIZE	0.000	0.000	0.576	-0.001	0.000
MARK	-0.147***	0.049	0.003	-0.243	-0.051
JESSORE	-0.452***	0.152	0.003	-0.750	-0.153
COMILLA	-0.655***	0.174	0.000	-0.997	-0.313
NILPHAMARI	0.319	0.356	0.371	-0.379	1.017
THAKURGION	-0.566***	0.197	0.004	-0.953	-0.179
_cut1	-1.711	0.542		(Ancillary	parameters)
_cut2	-0.793	0.531			
_cut3	0.050	0.530			
_cut4	0.775	0.531			
_cut5	1.295	0.534			
_cut6	1.755	0.539			
_cut7	2.162	0.545			
_cut8	2.587	0.557			

Single, double, and triple asterisks indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

The socio-economic variables that influence adoption of intermediate technologies are ORG, which positively affect adoption of intermediate IPM practices, and MARK, representing distance from a market in kilometers, which negatively affects it. These results are plausible because participating in an organization may positively influence adoption, while farmers who are further from the market have less access to information and thus decrease the chances of adoption. The various region variables are also significant in the regression. Farmers in Jessore, Comilla and Thakurgion are all significantly less likely to adopt intermediate IPM practices than farmers in Gazipur.

The marginal effects of the ordered probit for intermediate technologies, listed in Appendix B, are calculated for the different integer values of the dependent variable ranging from 0 to 8, which represent the number of simple technologies that a farmer may have adopted. No farmer in the sample adopted all nine intermediate technologies, so the marginal effects are not calculated for when the dependent variable equals nine. The results of the marginal effects demonstrate that when the dependant variable INTERMEDIATESCORE is seven, meaning that the respondent adopted seven of the possible nine intermediate technologies, FDAY has a positive coefficient of .028 and is significant at the 10% level. VISIT has a positive coefficient of .01 and is significant at the 5% level and FFS has a positive coefficient of .028 and is significant at the 1% level. These results indicate that field day participants, people visited by an agent, and FFS attendees are all significantly more likely to adopt a high number intermediate practices than those who did not attend these types of training.

Table 4.6 displays the results for factors influencing the adoption of complex IPM technologies and practices. MMEDIA has a negative coefficient, but the variable is not significant. The variables FDAY, VISIT and FFS all have positive coefficients indicating that they have a positive influence on the probability of adoption of complex practices. FDAY and FFS are both significant at the 1% level.

Table 4.6
Ordered Probit Regression Results for Adoption of Complex Technologies & Practices

Ordered probit estimates			Number of obs	=	350
			LR chi2(18)	=	146.00
			Prob > chi2	=	0.0000
Log likelihood = -343.24548			Pseudo R2	=	0.1754

COMPLEXSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MMEDIA	-0.534	0.517	0.302	-1.548	0.479
FDAY	0.757***	0.223	0.001	0.321	1.193
VISIT	0.120	0.142	0.397	-0.158	0.399
FFS	1.186***	0.149	0.000	0.893	1.478
AGE	0.078**	0.031	0.012	0.017	0.138
AGESQ	-0.001**	0.000	0.025	-0.002	0.000
FAM	0.009	0.028	0.756	-0.046	0.063
MALE	-0.190	0.266	0.477	-0.711	0.332
PRIM	-0.135	0.167	0.419	-0.462	0.192
HSSC	0.083	0.105	0.430	-0.123	0.289
DEG	-0.041	0.189	0.827	-0.412	0.330
ORG	0.336**	0.141	0.017	0.060	0.611
FARMSIZE	0.000	0.000	0.693	-0.001	0.000
MARK	0.031	0.055	0.570	-0.076	0.139
JESSORE	-1.355***	0.185	0.000	-1.717	-0.994
COMILLA	-0.718***	0.198	0.000	-1.107	-0.329
NILPHAMARI	-0.967**	0.402	0.016	-1.754	-0.180
THAKURGION	-1.377***	0.236	0.000	-1.839	-0.914
_cut1	1.395	0.667		(Ancillary	parameters)
_cut2	2.133	0.672			
_cut3	3.891	0.687			

Single, double, and triple asterisks indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

The socio-economic variables AGE and AGESQ are both statistically significant at the 5% level. AGE has a positive coefficient and AGESQ has a negative coefficient. The variable ORG is significant at the 5% level with a positive coefficient. All of the district variables are significant, with negative coefficients, indicating that farmers in the other districts of Bangladesh are significantly less likely to adopt complex IPM practices than farmers in Gazipur.

The marginal effects for complex technologies, listed in appendix B, are calculated for the different integer values of the dependent variable ranging from 0 to 3, which represent the number of complex technologies that a farmer may have adopted. The marginal effects results indicate when the dependent variable COMPLEXSCORE is three, meaning farmers have adopted all three complex technologies, both FDAY and FFS participants are significantly more likely to adopt all three complex technologies than farmers who did not attend FFS or field days. The FDAY variable is significant at the 10% level and has a positive coefficient of .05 while the FFS variable is significant at the 1% level and has a positive coefficient of .047.

Endogeneity

Chapter three presents a model to address the potential endogeneity that may exist for FFS participants. The results of the model are addressed in appendix C. The results of the endogeneity model demonstrate that there are several significant factors influencing FFS participation. MALE is one factor that negatively impacts participation in FFS. The fact that the MALE variable is negative and significant indicates that females are being selected into the FFS programs. Having an intermediate level of education, indicated by the variable HSSC, and having a received a degree, DEG, positively impact participation in FFS. The HSSC and the DEG, variables with positive coefficients indicates that farmers with some level of education are more likely than illiterate farmers to be in FFS. Participation in a community organization, indicated by the variable ORG, also positively impacts FFS. The significance of the ORG variable demonstrates that farmers involved in the community are more likely to be chosen to participate in FFS. FARMSIZE is also significant at the 5% level indicating that larger farmers are being selected into FFS. The variable COMILLA has a positive coefficient and is significantly different than GAZIPUR. The significance of the COMILLA variable indicates that more FFS have been run in COMILLA than in GAZIPUR.

The results of the ordered probit regressions for FFS participants gives some indication that AGE and AGESQ, having some level of education, being part of an organization and the different regional variables may have some influence on adoption of different types of IPM technologies and practices. The problem with the models presented in this appendix becomes evident when the predicted probability of FFS (PFFS) is included in the ordered probit regressions for the adoption scores. The effects of the FFS on adoption scores for simple, intermediate and complex technologies and practices are greatly reduced once the predicted probability of FFS participation (PFFS) is included in the ordered probit regression. The fact that the significance level of PFFS is reduced once the unexplained factors influencing participation in FFS that also influence adoption scores are controlled for is not surprising. It is however very unlikely that variable PFFS should be as insignificant as it is in the models for simple, intermediate and complex technologies presented in this appendix.

Comparing the regression results in this appendix with the results from the original adoption models in section IV.3.3 demonstrate that the significance level of PFFS in this appendix is much lower than the significance level of the FFS variable presented in the models in chapter 4. This difference in significance level may be due to the fact that the initial probit model in this appendix that predicts participation in FFS and is used to derive the predicted value of FFS (PFFS) is not well specified.

IV.3.4 Results for Appropriate Use of IPM

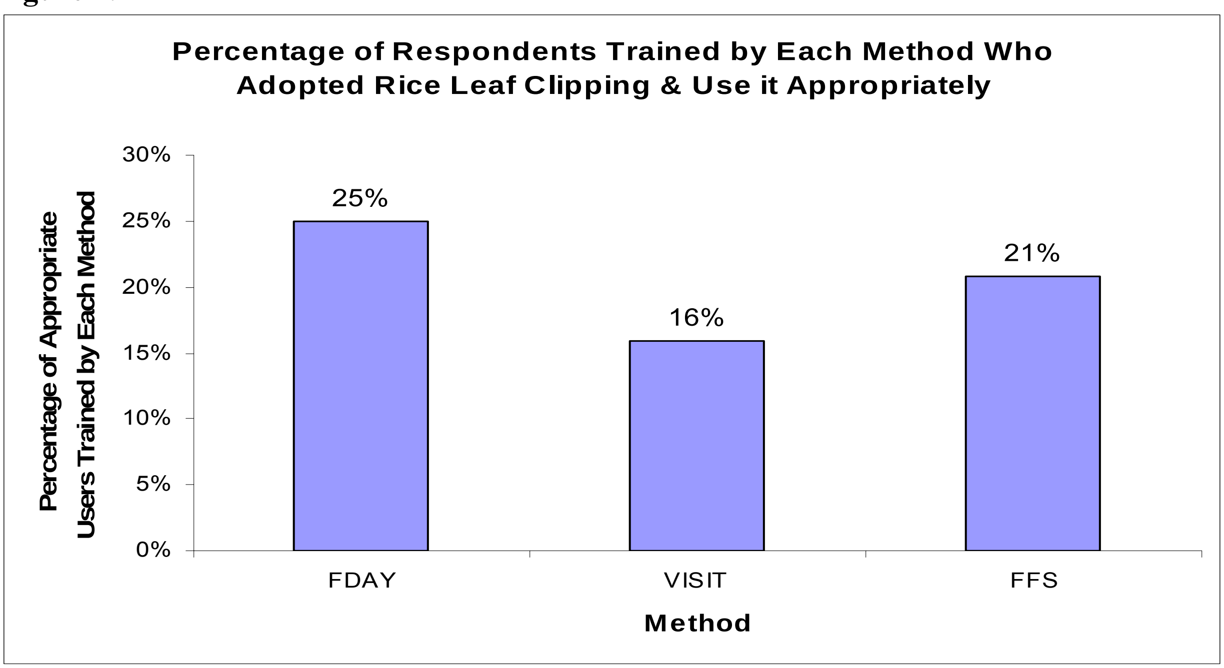
The following sub-section presents the results for the role of IPM training methods in influencing farmers to use IPM practices appropriately. The study analyzes two different practices, one a relatively simple practice of clipping infected rice leaves, and the other a more complex practice of using bait traps in sweet gourd to attract and trap fruit flies. The leaf clipping practice and the bait trap technology are listed as intermediate practices both in the survey and for the ordered probit model in the previous section measuring adoption. The leaf clipping practices is clearly a much simpler practice requires less understanding and management of IPM than the bait trap technology. For the purpose of measuring appropriate use in this study, leaf clipping represents the simpler practice and bait traps represents the more complex technology.

Farms' ability to use the IPM technologies appropriately is determined by asking questions in the survey that test how respondents' apply the practices on their farms. Farmers are deemed appropriate users if their answers to how they use the practice were similar to the best management practices determined by the researchers at BARI and the IPM CRSP who worked to develop and adapt the IPM technologies in Bangladesh. Descriptive statistics and regression results are presented for the two different practices and conclusions are drawn about different methods' impacts on appropriate use for the simple and the more complex technology. For both the rice clipping practice and the bait trap technology results of the initial adoption probit model are included in Appendix C and the results of the probit model for appropriate use are presented in this section of the chapter.

Leaf Clipping in Rice

There are 163 farmers in the sample who adopted the rice leaf clipping practice. Only 30 of those farmers use the practice correctly by clipping the leaves 60-70 days after transplanting. Figure 4.2 displays the percentage of farmers in the sample who have been trained through the various methods that adopted rice leaf clipping and use the practice appropriately. Some of the 30 appropriate users had been to more than one type of IPM training. The figure demonstrates that none of the methods has an extremely high percentage of appropriate users, for example, only 16% of adopters who received a visit use the practice appropriately. Only 21% of FFS adopters use the practice appropriately, while the highest percentage of adopters that use it appropriately came from those who had been to a field day. These results indicate that for a simple practice such as leaf clipping a less intense method such as a field day may be only slightly more effective than the more intense methods at training farmers to use the practice appropriately, but the difference is not substantial.

Figure 4.2



The regression results for the dichotomous probit model used to measure the factors that influence adoption of rice leaf clipping are presented in Appendix C while the results for the dichotomous probit model used to measure the factors that influence appropriate use of rice leaf clipping are presented in table 4.7. The results indicate the difficulty in econometrically measuring the factors that influence appropriate use of IPM technologies and practices. The adoption model in Appendix C is significant at the 1% level while the appropriate use model in table 4.7 is significant at only the 10% level. In the appropriate use regression, MMEDIA predicts failure perfectly so the variable and four observations are dropped from the regression. The variables, FDAY, VISIT and FFS all have negative coefficients, indicating a negative impact on appropriate use of rice leaf clipping but the variables are not statistically significant. The variable MILLS, representing the inverse mills ratio is also not significant, indicating that endogeneity does not have a significant impact on influencing appropriate use.

Table 4.7
Appropriate Use of Rice Leaf Clipping Practice

Probit Estimates — Number of Obs = 159; LR chi2 (16) = 23.720; Prob > chi2 = 0.096; Pseudo R2 = 0.154

Log likelihood = -65.144

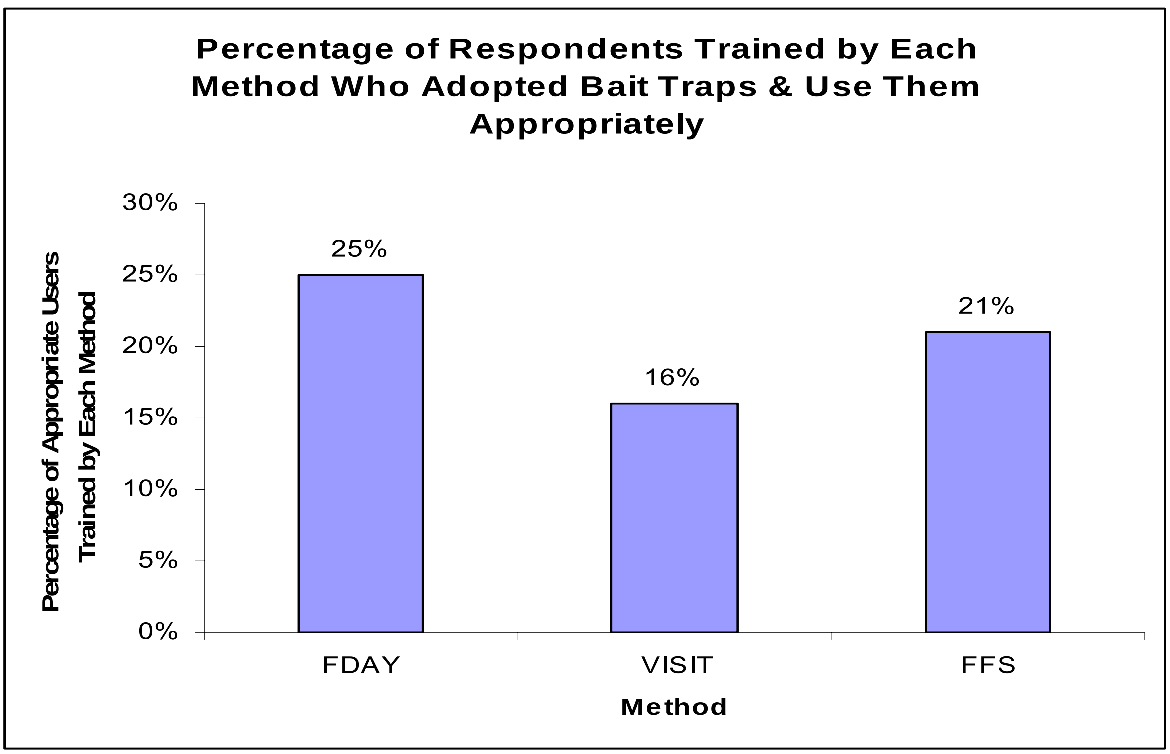
CLIPAPPROP	COEF.	STD. ERR.	P>Z	[95%	CONF. INTERVAL]
MILLS	-2.811	2.951	0.341	-8.595	2.974
FDAY	-0.283	0.638	0.657	-1.534	0.967
VISIT	-0.415	0.381	0.275	-1.162	0.331
FFS	-1.214	1.223	0.321	-3.611	1.183
AGE	-0.001	0.048	0.987	-0.095	0.093
AGESQ	0.000	0.001	0.789	-0.002	0.001
FAM	0.007	0.050	0.891	-0.091	0.105
MALE	-1.633	1.532	0.286	-4.636	1.369
PRIM	-0.038	0.509	0.940	-1.035	0.959
HSSC	0.538	0.517	0.298	-0.474	1.551
DEG	-0.064	1.007	0.949	-2.037	1.910
ORG	-1.045	0.840	0.213	-2.691	0.601
THREEORMORE	0.062	0.289	0.831	-0.505	0.629
JESSORE	2.110	1.475	0.153	-0.782	5.001
COMILLA	1.826	1.573	0.245	-1.256	4.909
NORTHERN	2.875	1.768	0.104	-0.591	6.341
_CONS	3.219	4.815	0.504	-6.218	12.656

Single, double, and triple asterisks indicate the corresponding coefficients in the probit model are significant at the 10%, 5% and 1% level respectively.

Bait Traps in Gourds

There are 103 farmers in the sample who adopted the mashed sweet gourd bait trap technology. Of those 103 farmers 48 respondents know how to use the technology appropriately by changing the bait trap twice a week. Figure 4.3 displays the percentage of respondents who have been trained by each method that adopted the practice and use it appropriately. Some of the 48 appropriate users had been to more than one type of training. Forty percent of field day participants and 44% of FFS participants who adopted bait traps use the technology appropriately while 49% of farmers who received a visit used bait traps in the appropriate manner. Figure 4.3 indicates that in the case of the more complex bait trap technology, the moderately intense agent visit method and the more intense FFS method may be slightly more effective at influencing a greater percentage of adopters to use the practice appropriately then are less intense methods but the difference is not substantial.

Figure 4.3



The regression results for the dichotomous probit model used to measure the factors that influence adoption of the bait trap technology are presented in Appendix C while the results for the dichotomous probit model that is used to measure the factors that influence appropriate use of bait traps are presented in table 4.8. The results from appendix C indicate that FDAY and FFS have positive coefficients and are significant at influencing the probability of bait trap adoption at the 1% level. The results in Table 4.8 demonstrate that VISIT has a positive coefficient but none of the variables are statistically significant at influencing appropriate use of bait traps. The mills variable has a positive coefficient and is significant at the 10% level, indicating that endogeneity may be significant in influencing appropriate users of the bait trap technology.

Table 4.8
Appropriate Use of Bait Trap Technology

Probit estimates — Number of obs = 103; LR chi2 (17) = 32.190; Prob > chi2 = 0.014; Log likelihood = -55.061; Pseudo R2 = 0.2262

TRAPAPPROP	COEF.	STD. ERR.	P>Z	[95%	CONF. INTERVAL]
MILLS	0.164	1.710	0.923	-3.186	3.515
MMEDIA	-0.003	0.876	0.997	-1.720	1.714
FDAY	-0.106	1.276	0.934	-2.607	2.396
VISIT	0.130	0.431	0.763	-0.714	0.975
FFS	-0.808	0.717	0.260	-2.214	0.598
AGE	0.093	0.083	0.265	-0.070	0.256
AGESQ	-0.001	0.001	0.194	-0.003	0.001
FAM	-0.002	0.080	0.975	-0.159	0.154
MALE	-0.539	0.653	0.409	-1.820	0.742
PRIM	-0.214	0.677	0.752	-1.540	1.112
HSSC	-1.012*	0.601	0.092	-2.189	0.166
DEG	-1.070	0.696	0.124	-2.433	0.294
ORG	0.640	0.435	0.141	-0.213	1.493
JESSORE	-0.839	0.681	0.218	-2.174	0.496
COMILLA	0.820*	0.426	0.054	-0.015	1.656
NORTHERN	-1.055*	0.627	0.093	-2.285	0.175
THREEORMORE	-0.396	0.371	0.285	-1.122	0.330
_CONS	-0.318	3.907	0.935	-7.976	7.341

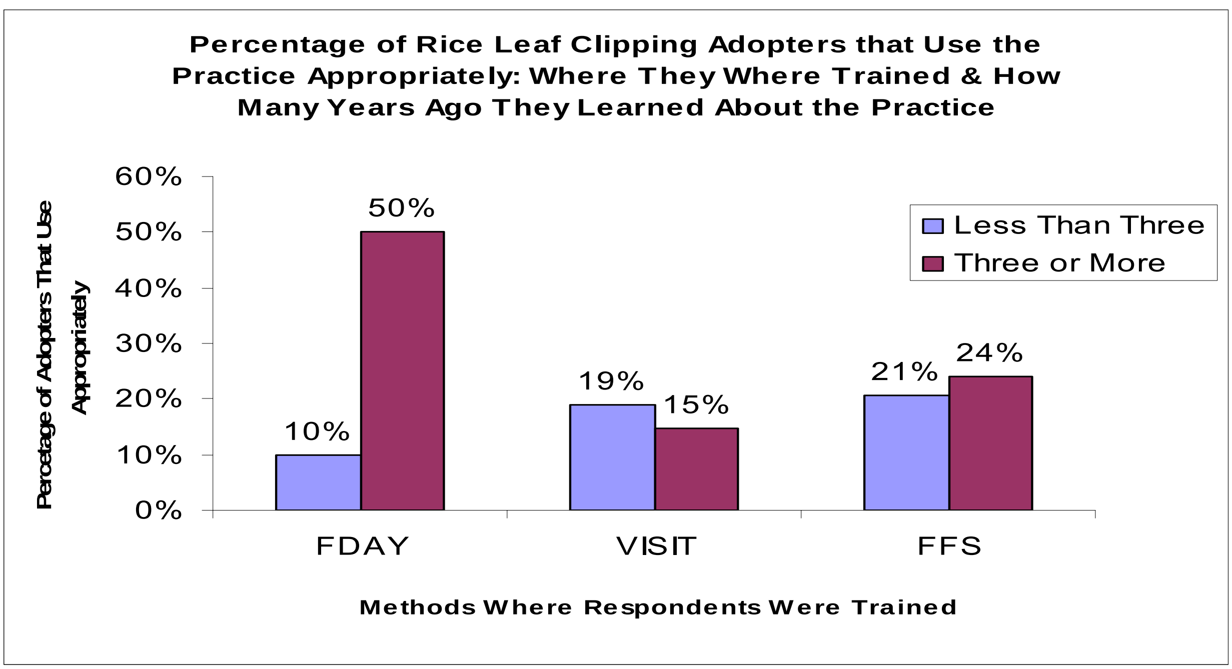
Single, double, and triple asterisks indicate the corresponding coefficients in the probit model are significant at the 10%, 5% and 1% level respectively.

The results of this section measuring appropriate use indicate that it is not possible to determine if certain methods are more likely to influence appropriate use than other methods.

IV.3.5 Results for Influencing Retention of IPM Technologies and Practices

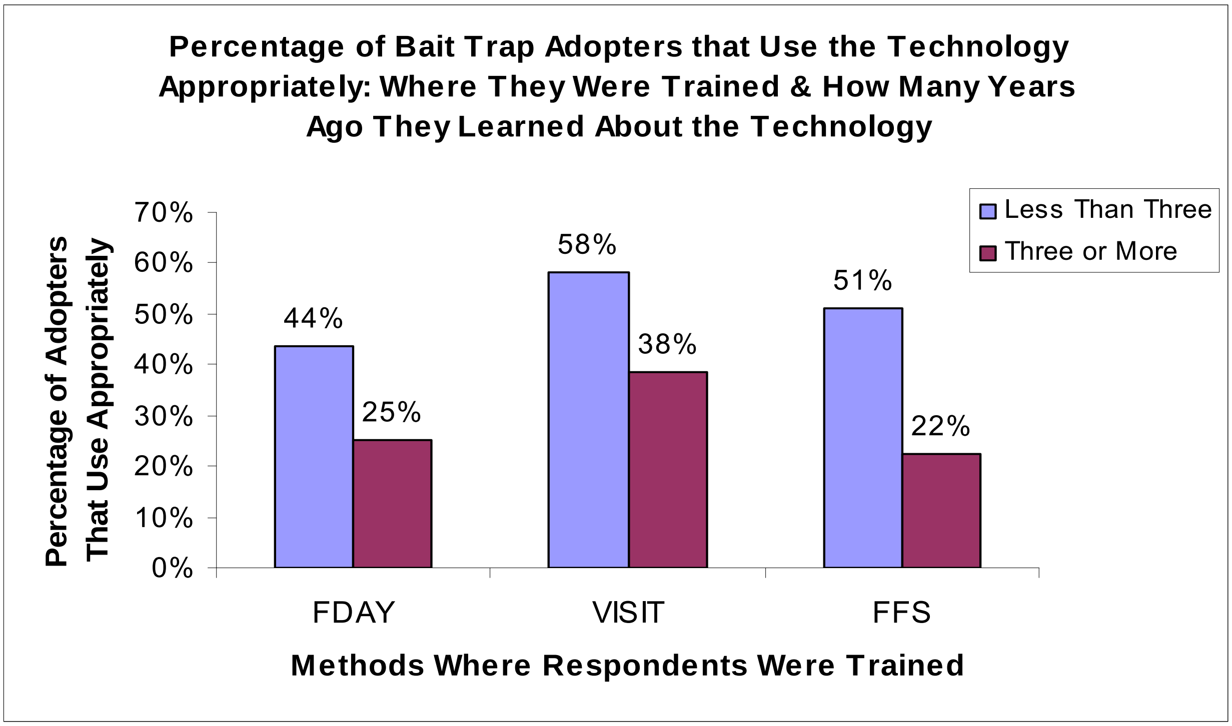
This section provides insight into how different methods influence retention of simple and more complex IPM technologies and practices. Figure 4.4 displays the percentage of adopters in the sample who use the practice appropriately, how many years ago they learned about the practice and what types of training they have had. Of the 30 respondents who knew how to use the rice clipping practice appropriately, 17 learned about it less than three years ago while 13 learned about it three or more years ago. Some of the respondents have been to more than one type of training method. Figure 4.4 demonstrates that a greater percentage of field day participants who adopted and use the practice appropriately learned about it three or more years ago. A greater percentage of farmers who received a visit and then adopted and used leaf clipping appropriately, learned about the practice less than three years ago. In the case of farmers who attended FFS, a slightly greater percentage of adopters who use rice clipping appropriately learned about the practice three or more years ago. These results show that for the simple rice clipping practice, a greater percentage of farmers trained by the less intense field day method and the more intense FFS methods who use the practice appropriately, actually were exposed three or more years ago. These findings give a slight indication that farmers trained by field days and FFS may be retaining information of simple practices over time.

Figure 4.4



There are 48 farmers who use the bait trap technology appropriately, 40 learned about the practice less than three years ago, and eight learned about it three or more years ago. Some of the 48 appropriate users have received more than one type of IPM training. Figure 4.5 demonstrates that for all of the different diffusion methods, a greater percentage of adopters who use the bait traps appropriately learned about the technology less than three years ago. These results indicate that perhaps in the case of a more complex practice, farmers are less likely to retain information over time. The findings also indicate that there are similar percentages of appropriate users among those who have been to different types of training programs.

Figure 4.5



The regression results from Table 4.7 and Table 4.8 in section IV.3.4 provide information about whether there is a difference in retention over time between simple and more complex IPM practices and technologies. The appropriate use regression for rice leaf clipping demonstrates that the variable THREEORMORE has a positive coefficient but is not significant (Table 4.7). This result indicates that there is no significant difference in retention rates between farmers who learned about rice clipping, a simple technology, less than three years ago and those who learned about it more than three years ago. With sweet gourd traps, a more complex practice the coefficient for the THREEORMORE variable is negative and not significant (Table 4.8). This result indicates that farmers may be less likely to use the practice appropriately if they learned about it three or more years ago as opposed to learning about it sooner. The overall findings of these regressions indicate that there is no significant difference in retention between farmers who use simple practices such as rice leaf clipping, but there may be some slight difference in retention for more complex practices such as mashed sweet gourd traps.

IV.3.6 Results for Influencing Adaptability of IPM on the Farm

Results of this sub-section identify the training methods and socio-economic factors that influence farmers to discover IPM practices through their own experimentation. The study assumes that farmers who develop IPM techniques on their own are innovative and have been able to adapt information from one situation to another. The correlation between a farmer discovering an IPM practice through his or her own experience and other factors that may influence the probability of discovery through experimentation are presented in Table 4.9. The factors with the highest positive correlation to OWNEXPERIENCE are FDAY, VISIT, FFS, AGE, AGESQ, DEG, JESSORE and COMILLA. It is logical that the variables representing formal training methods such as FDAY, VIST and FFS are correlated with OWNEXPERIENCE because one would expect those who have learned about IPM practices from formal methods to have enough knowledge to apply it to other areas on their farm. The AGE variables are logically correlated because it is reasonable to assume that older farmers have had more time to make discoveries through experimentation than younger farmers and farmers with more education are likely more innovative and are able to transfer knowledge to various areas of the farm.

Table 4.9
Correlation Between Own Experience and Other Factors

	OWNEXPER
OWNEXPER	1.000
MMEDIA	-0.092
FDAY	0.115
VISIT	0.108
FFS	0.091
AGE	0.088
AGESQ	0.070
FAM	0.042
MALE	0.044
PRIM	0.013
HSSC	0.024
DEG	0.096
ORG	-0.036
FARMSIZE	-0.054
MARK	0.040
GAZIPUR	-0.402
JESSORE	0.123
COMILLA	0.276
NORTHERN	0.023

The regression results presented in Table 4.10 show the factors that influence discovery through experimentation. The dependent variable for the adaptability probit, takes on a value of zero if the farmer has not discovered any IPM practices through their own experimentation and a one if he or she has. The VISIT variable is the only variable representing a formal method that is statistically significant. VISIT is significant at the 1% level and has a positive coefficient. This finding may indicate that farmers who have received visits from an agent have learned skills that they have been able to apply to other areas on their farm. FDAY also has a positive coefficient but is only significant at the 20% level. MMEDIA has a negative coefficient but is also significant at only the 20% level.

Table 4.10
Adaptability Regression

Probit estimates				Number of obs =	350
				LR chi2(17) =	95.480
				Prob > chi2 =	0.000
Log likelihood = -176.623				Pseudo R2 =	0.213

OWNEXPER	COEF.	STD. ERR.	P>Z	[95%	CONF. INTERVAL]
MMEDIA	-0.643	0.490	0.189	-1.602	0.317
FDAY	0.408	0.296	0.168	-0.172	0.987
VISIT	0.551	0.173	0.001	0.212	0.890
FFS	0.168	0.173	0.332	-0.172	0.508
AGE	0.062	0.030	0.039	0.003	0.122
AGESQ	-0.001	0.000	0.119	-0.001	0.000
FAM	-0.023	0.033	0.477	-0.088	0.041
MALE	0.283	0.312	0.365	-0.329	0.895
PRIM	0.162	0.208	0.435	-0.245	0.570
HSSC	0.111	0.163	0.498	-0.209	0.430
DEG	0.362	0.259	0.162	-0.145	0.870
ORG	-0.141	0.172	0.413	-0.479	0.197
FARMSIZE	0.000	0.000	0.500	-0.001	0.000
MARK	0.093	0.068	0.175	-0.041	0.226
JESSORE	0.996	0.205	0.000	0.595	1.397
COMILLA	1.751	0.264	0.000	1.234	2.269
NORTHERN	0.986	0.241	0.000	0.514	1.459
_CONS	-2.598	0.734	0.000	-4.036	-1.159

Single, double, and triple asterisks indicate the corresponding coefficients in the probit model are significant at the 10%, 5% and 1% level respectively.

The regions of the country all have positive coefficients and are significantly different from the Gazipur district at the 1% level. This difference could result from the fact that Gazipur is located in close proximity to Dhaka and the various agricultural research institutes such as BARI and BRRI. Since farmers in Gazipur have these resources nearby there may be less incentive for them to invent and discover on their own. AGE has a positive coefficient and is significant at only the 20% level while AGESQ has a negative coefficient and is also significant at only the 20% level. DEG and MARK both have positive coefficients and are only significant at the 20% level.

The marginal effects of the adaptability regression are presented in Appendix E. The marginal effects demonstrate that farmers who have received a visit from an agent are 20% more likely to have discovered a practice on their own than farmers who did not learn about IPM from an agent. The VISIT variable is significant at the 1% level. The variable FDAY has a coefficient of .128 but is only significant at the 20% level.

IV.3.7 Results for Accessibility to Limited Resource Farmers

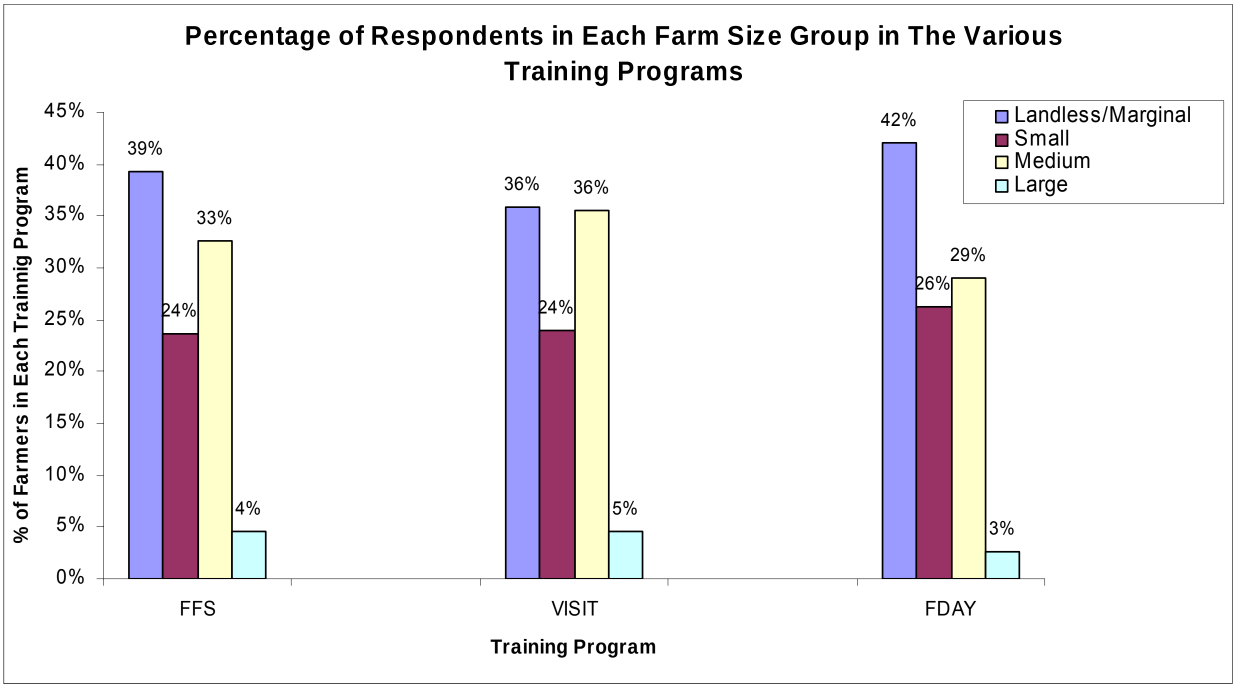
The accessibility of IPM diffusion methods to farmers with limited resources is another component of effectiveness that is measured in this study. Income is assumed to be based on farm size, measured in decimals, (100 decimals = 1 acre). In Bangladesh, farmers are classified as *landless* if they have less than .5 acres, *marginal* if they maintain between 1.49 acres, *small* if they cultivate between 1.5 and 2.5 acres, *medium* if they farm between 2.5 and 7.5 acres and *large* if they own more than 7.5 acres (Ministry of Agriculture, 2003C). Of the 350 farmers in the sample, 143 are landless or marginal farmers, 85 are small farmers, 110 are medium farmers and 12 are large farmers. Table 4.11 displays the number of farmers in the sample in each farm size that have attended the various training programs. The numbers in the table add up to more than 350 because some farmers have attended multiple training programs. Table 4.11 shows that of the 12 large farmers in the sample 11 have received a visit from an agent and 8 have attended FFS. These numbers indicate that agent visits and FFS serve a higher percentage of the large farmers than small farmers in the sample.

Table 4.11
Training Programs Attended By Respondents in Each Farm Size Group

	Field Day	Visit	FFS
Landless/Marginal	16	87	70
Small	10	58	42
Medium	11	86	58
Large	1	11	8

Figure 4.6 shows the percentages that the various farm size groups represent in the different training methods. The figure demonstrates that landless, marginal and small farmers make up a significant percentage of the participants in each program, indicating that they have access to the programs. The results from this section indicate that producers in each farm size group are represented in the different IPM training programs however a higher percentage of large farmers have been to FFS or received an agent visit compared to small and marginal farmers.

Figure 4.6



IV.3.8 Results for Informal Diffusion of IPM

Measuring how information is spread informally among members of a community from people who have attended a training program to other farmers in the village who have not been formally trained is a component related to how many farmers the training method reaches with a given budget. When information is spread informally, more people are able to use that information. Informal diffusion is important for maintaining cost-effective IPM training programs because not everyone can be reached by a formal method so secondary spread of information allows more people to receive the information. Table 4.12 presents a T-test measuring the difference between farmers in villages with FFS and farmers in villages without FFS, in the number of times respondents mention hearing about IPM technologies and practices from neighbors or relatives.

Table 4.12
Difference in Informal Diffusion between Farmers in FFS Villages and Farmers in Non-FFS Villages

t-Test: Two-Sample Assuming Equal Variances		
	FFS VILLAGE	**NON-FFS VILLAGE**
Mean	3.792	5.484
Variance	8.925	6.778
Observations	288.000	62.000
Pooled Variance	8.549	
Hypothesized Mean Difference	0.000	
Df	348.000	
t Stat	-4.134	
P(T<=t) one-tail	0.000	
t Critical one-tail	1.649	
P(T<=t) two-tail	0.000	
t Critical two-tail	1.967	

The results of Table 4.12 demonstrate that respondents in the non-FFS village report a higher mean value for the number of IPM practices and technologies they have learned about from informal sources such as neighbors and relatives. The T-statistic is negative and significantly different from zero for both the one-tail and two-tail test, indicating that farmers in the FFS village are statistically different from farmers in the non-FFS village and they are less likely to have heard about IPM practices from other farmers. This result may be caused by farmers in the non-FFS village relying on one another for information, while farmers in the FFS village receive most of their information from the FFS itself. Another reason could be that the IPM training methods that have occurred in the non-FFS villages, such as agent visits and field days, may be more effective than FFS at encouraging informal diffusion of information. The difference in number of technologies learned about from informal sources could also be caused by unobservable social factors that exist in the different villages.

The regression results for the informal diffusion model are presented in Appendix F. Table F.1 demonstrates that for knowledge of simple IPM practices, the variable TRAINED, representing farmers who have been to FFS has a positive coefficient, and is significant at the 1% level. The variable EXPOSED, representing non-FFS farmers in a village with FFS, also has a positive coefficient and is significant at the 1% level. These results indicate that FFS trained farmers have heard about a greater number of simple practices than farmers in the control group with no FFS in their village. The findings also show that exposed farmers in the FFS village have heard about more simple practices than the control group of farmers who live in villages with no FFS. These results indicate that FFS farmers may be sharing simple practices with other farmers in their village.

Table F.2 shows the results of respondents' awareness of intermediate IPM practices. The TRAINED variable again has a positive coefficient and is significant at the 1% level. This indicates that FFS trained farmers have heard about a greater number of intermediate practices than farmers in the control group. The EXPOSED variable has a negative coefficient and is significant at the 5% level. This means that exposed farmers in the FFS village have heard about fewer intermediate IPM practices then farmers in the control village. Since FFS trained farmers have heard about significantly more intermediate practices than the control group while the farmers in their village who did not go to FFS have heard about significantly fewer intermediate practices than the control group, it calls into question how much intermediate information FFS trained farmers are sharing with their neighbors. It may be that the farmers in the control group, some of who have been to other less intense training methods such as field days and agent visits are learning about a greater number of IPM practices than are the farmers in the exposed group.

Table F.3 presents the results of respondents' awareness of complex IPM practices. The TRAINED variable again has a positive coefficient and is significant at the 1% level. This indicates that FFS trained farmers have heard about a greater number of complex IPM practices than farmers in the control group. The variable EXPOSED has a negative coefficient but is not significant. This finding shows that there is no significant difference between the number of complex IPM practices that exposed farmers are aware of and the number of complex practices that farmers in the control village have heard about. Table F.4 displays the results of respondents' awareness of all types of IPM practices. The variable TRAINED is positive and significant at the 1% level. The EXPOSED variable has a negative coefficient but is not significantly different from the control group.

The results from this section show that FFS participants are aware of more IPM technologies and practices than farmers in other groups but it is not clear whether information diffusion is any greater in the FFS village than it is in other villages. The control group of farmers who live in villages with no FFS are aware of fewer simple practices than the exposed group who live in the FFS villages but did not attend the training. This result indicates that FFS farmers may be discussing simple practices with other farmers in their village and it seems logical that this might happen because simple practices require little time and effort to explain to others. Conversely, the exposed group is aware of significantly fewer intermediate practices than the control group. This finding could mean that less intense training methods that occur in the control villages, such as agent visits and field days, are more effective at informing farmers about intermediate practices than FFS farmers are at spreading these practices informally in their villages. The lack of informal diffusion in of intermediate practices FFS villages could be because these practices are fairly complicated to understand and require more time to explain so FFS farmers are not as inclined take the time to educate others. The control group and the exposed group are not significantly different in the case of complex practices. This result indicates that FFS farmers are no better than the agent visits and field days that occur in the non-FFS villages at diffusing complex information. The fact that informal diffusion is not more effective in the FFS villages could again be caused by the complexity of the information that would require farmers to take more time in order to share it with others. These results suggest that while FFS graduates may share simple practice with others, they should not be relied upon as the only means of diffusing more complex practices to other farmers.

IV.4 Cost Results

The following section describes the costs of administering IPM diffusion methods in Bangladesh. Costs for less intense, moderately intense and more intense dissemination methods are outlined below. All of the cost information that was available to for the study is detailed in this section. The costs that the study examines for use in the overall cost-effectiveness measurement are the variable field cost of administering the training methods, the opportunity cost of the trainers who conduct the training, and the opportunity cost to farmers who participate in the various IPM training methods. In the following section, this cost component is evaluated along with aspects of the effectiveness results from the previous section in order to estimate an overall measure of cost-effectiveness for the IPM diffusion methods.

IV.4.1 Cost of Less Intensive Methods

Cost information for less intensive training methods such as, mass media and field day demonstrations administered by BARI and the IPM CRSP are described below. Cost information is not available for any mass media methods however there is detailed information about the costs of other less intensive methods such as the field day demonstrations which have been found to clearly impact IPM diffusion.

The cost of administering both BARI and IPM CRSP field day demonstrations are listed in tables 4.13 and 4.14. The cost for a BARI field day, outlined in Table 4.13, is US $1,467. This cost should be regarded as the variable field cost of conducting each additional field day because a number of fixed costs, including the cost of developing and running the central offices are not included in the table. The per farmer variable field cost of the BARI field day is ($1,467/400 participants) equal to $3.67.

Table 4.13
Cost for BARI/DFID Field Days

ITEMS	COST PER ITEM	TOTAL COST	
		BD Taka	**US $**
Farmers' Conveyance and Food Allowance	200 Taka X 400 Farmers	80,000	1,333.34
Other costs (audio-visual, oil fuel etc.)	3000 Taka	3,000	50.34
Pandel related costs	5000 Taka	5,000	83.33
Total Field Day Costs		**88,000**	**1,4667**
		Source: Dr. S.N. Alam, 2005	

The costs for IPM CRSP field days are detailed in Table 4.14. The costs for the IPM CRSP field day is higher than for the BARI sponsored field day due to the additional side costs such as brochures, and invitation cards that the IPM CRSP provides. The costs described in Table 4.14 are also the variable field costs because the trainers' salaries and other fixed costs such as the budget for the central office are not available and are not included in the table. The total variable field cost for the IPM CRSP field day demonstration is US $2,996. Costs such as stage, decorations, banners and demonstration boards are treated as sunk costs and can be removed from the expense sheet because they can be used in future field days. When the sunk costs are not considered in the calculation, the variable field cost of the field day equals US $2,627. The field cost per farmer is equal to ($2,627/400 participants) or US $6.57. The cost-effectiveness analysis uses the average of the BARI/DFID field day and the IPM CRSP field day. The average variable field cost for a field day cost is equal to ($3.67 + $6.57)/2 or $5.12.

Table 4.14
Costs for IPM CRSP Field Days

ITEMS	TOTAL COST	
	BD Taka	**US $**
Field day stage & decoration	20,741.00	345.68
Brochure & Invitation Cards	24,833.00	413.88
Office Stationary	9,843.00	164.05
Field Day banner	670.00	11.17
Demonstration Boards	10,965.50	182.76
Travels (Domestic)	11,760.00	196.00
Vehicle		
Fuel & Incidental Costs	27,080.50	451.34
Rent	38,800.00	646.67
Lunch & Tea	34,161.00	569.35
Video Recording	835.00	13.92
Other Incidental Costs	90.00	1.50
Total Costs	**179,779.00**	**2,997**
	Source: IPM CRSP budget, 2004	

The opportunity cost for the trainers who run the field days should be estimated because the scientist from BARI or the IPM CRSP who run the trainings could use that time to engage in other productive activities. The opportunity cost estimation assumes that five scientists conduct the training and each earns a salary of $150 per month. It is assumed that a field day is conducted every other month or six times a year. When one field day lasts one full day every other month, it takes up one half of a work day per month. Assuming that there are 20 work days in a four week month then holding a field day every other month constitutes 1/40 of a work month. The five scientist trainers earn a combined $750 per month ($150.00 * 5 scientists) so 1/40 of their total salary is $18.75. The value of $18.75 is the opportunity cost for having scientists run the field day so the opportunity cost per farmer trained through the field day is ($18.75/400 participants) or $.05 per farmer.

IV.4.2 Cost of Moderately Intensive Methods

There is ample information available about the costs of extension agents visiting farmers. The cost associated with agent visits are agents' annual salary and variable field costs such as food and transportation associated with visiting farmers. Table 4.15 demonstrates that the average annual salary for a BS in Bangladesh is US $1,232.00 or around US $103.00 per month.

The opportunity cost of the agent's time is calculated by assuming that the agent spends 25% of his time speaking to farmers about IPM and 75% of the time working with farmers on other activities such as fertilizer application and livestock. The value of the agent's time spent on IPM is therefore around $26.00 per month. If one assumes that he is able to speak with 10 farmers in one month about IPM then the opportunity cost per farmer of the agent is equal to ($26.00/10 farmers) or $2.60. In addition to this per farmer opportunity cost, if the farmer is allocated 100 taka for travel and 20 taka for food for each farmer he visits, then the variable field cost equals (20tk * 10 farmers + 100 tk) or 300 tk per month which is around US $5.00 per month. $5.00 divided by 10 farmers equals a variable field cost of around $.50 per farmer.

Table 4.15
Annual Salary of Extension Agent

SALARY COMPONENTS	COST PER MONTH	TOTAL COST PER YEAR	
	(60 Taka = 1 US $)	BD Taka	US $
Monthly Salary	3,675 Taka X 12 Months	44,100	735.00
Housing Allowance	1,654 Taka X 12 Months	19,848	330.80
Expense Allowance	331 Taka X 12 Months	3,972	66.20
Medical Allowance	400 Taka X 12 Months	4,800	80.00
Other Allowance	100 Taka X 12 Months	1,200	20.00
Total Annual Salary		**73,920**	**1,232.00**
		Source: Dr. ANM Rezaul Karim, 2005	

The total annual budget for the IPM CRSP program in Bangladesh is slightly less than US $100,000. US $30,000 goes to run the IPM CRSP office at BARI including the consultants and employees, while most of the rest of the money goes to research. There is also little cost information about the specific cost of training farmers through visits from the IPM CRSP. The budget for the CRSP trainers to visit farmers in Bangladesh is mostly a fixed cost as the trainers' salaries are included in the annual budget. The only variable field cost is the cost of transportation and some food for the trainers and farmers. There is also an opportunity cost of the IPM CRSP employees' time since if they are not conducting a visit they could be engaged in some other endeavor. Since the IPM CRSP visit and the extension agent visits are similar training methods, this study assumes that the marginal cost for the IPM CRSP visits are identical to cost of agent visits.

IV.4.3 Cost of More Intensive Methods

The total costs for administering the DAE FFS program are listed in table 4.16 below. The total cost of administering the national level IPM policy, that has a mandate to educate 1.72

million farmers by 2014, is US $46,579,833. The average total cost per farmer trained through a DAEFFS is US $27.08 and the average cost per FFS is ($27.08 X 25 participants) equal to US $677.00.

Table 4.16
Costs for DAE/DANIDA FFS Program

	US $	US $
Policy Component	**Phase 1 (2005 -2009)**	**Phase 2 (2010 – 2014)**
Maintaining Ecological Balance Lumpsum, for i.e. organic farming/certification etc.	833,333	833,333
Executing appropriate actions on pesticides		
review legislation	166,667	-
Lumpsum for pesticide monitoring systems	416,667	416,667
Operating an effective system for implementing the national IPM program and developing human resources as the core of IPM		
Consultants and trainers	4,500,000	4,750,000
DAE led FFS	8,750,000	12,500,000
Farmer led FFS	1,687,500	5,812,500
Conducting research on IPM	-	-
Research FFS	202,500	112,500
Research support on basis of the FFS	166,667	416,667
Subtotal for investment	**16,723,333**	**22,591,667**
Contingency 10%	1,672,333	2,259,167
Depreciation of existing and new capital goods	1,666,667	1,666,667
5 year budget for implementation	20,062,333	26,517,500
Grand Total for Phase 1 + 2		**46,579,833**

Source: Draft IPM Strategy & Action Plan, 2004

The variable field cost associated with running each individual farmers field school is outlined in Table 4.17. The fixed costs of running the central administrative office in Dhaka are excluded from this table, so the total variable field cost for each FFS is US $250.00 and the variable field cost per farmer is ($250/25) or US $10.00. Additional costs such as startup, recruitment, transportation and obtaining a meeting area are not included in table 4.17. The field cost of administering farmer field schools may be higher than the tables and calculations in this section indicate.

Table 4.17
Budget for Running Individual FFS (Field Costs)

ITEMS	COST PER ITEM	TOTAL COST	
		BD Taka	US $
Refreshments for 1st Session	20 Taka X 40 People	800	13.34
Refreshments 12 regular sessions	10 Taka X 30 People X 12 Sessions	3,600	60.00
Field Day Preparation	1,100 Taka	1,100	18.34
Field Day Refreshments	10 Taka X 300 People	3,000	50.00
Honorarium for Trained AAO/AEO	125 Taka X 14 sessions	1,750	29.17
Honorarium for Trained BS	100 Taka X 14 sessions	1,400	23.34
Honorarium for local, untrained BS	50 Taka X 14 sessions	700	11.67
Monitoring, 3 visits in each FFS	200 Taka X 3 visits	600	10.00
Training and Materials	2,050 Taka	2,050	34.17
Total Budget for each FFS (with trained BS and untrained BS)		**15,000**	**250.00**
		Source: Guidelines for FFS, 2003	

The opportunity cost of the field day training is calculated based on the fact that, as Table 4.17 indicates, the Additional Agricultural Officer (AAO), the two Block Supervisors (BS), and the monitor who visits the FFS three times are all employees of the government and paid a stipend for their work during the FFS. If these government employees were not conducting the training, they would presumably be engaged in other productive activities. It is assumed that the two BS make $103.00 per month (see table 4.15) and the AAO and the monitor each earn $125.00 per month. Each FFS meets once a week for one half (.5) day. Meeting once a week means that there are four half day FFS sessions in a month which occupy two full work days. Assuming that there are 20 work days in a four week month, the FFS training takes up 1/10 of the two BS and AAO's time. The monitor who is at the FFS for one half day a month has 1/40 of his productive time occupied by the FFS. The total opportunity cost for the FFS Trainers' time is calculated in table 4.18.

Table 4.18
Opportunity Cost Estimation of FFS Trainers' Time

Trainer	Proportion of Time * Monthly Salary	Opportunity Cost
Block Supervisor 1st	.1 * $103.00	$10.30
Block Supervisor 2nd	.1 * $103.00	$10.30
Additional Ag. Officer	.1 * $125.00	$12.50
Monitor	.025 * 125.00	$3.13
TOTAL OPPORTUNITY COST PER FFS		$36.23

The total opportunity cost for the trainers' time spent per FFS equals $36.23. When this sum is divided by the 25 farmers who attend each FFS the opportunity cost per farmer is $1.45.

There is limited information available as to the cost of administering the CARE FFS. Due to the lack of information and the similarities between the two types of FFS training methods, it is assumed that both of these methods have the same variable field cost and opportunity cost for trainers.

IV.4.4 Costs to Farmers

The final cost component that must be considered when determining the cost of the different diffusion methods is the cost that farmers must bear in order to participate in the trainings. Farmers may pay either in participation fees or in the opportunity cost of their time spent in the training. Although they may pay for some extension service through taxes, results from the study indicate that none of the training methods charge their participants directly. Without requiring any direct payments, the only cost to participants is the opportunity cost of their time spent in the training sessions.

The opportunity cost to farmers who participate in various types of training methods is estimated in Table 4.19. The calculations in Table 4.19 are based on a number of assumptions including calculating the farmers' opportunity cost based on an assumed farm income of US $1.00 per day. The duration of the various methods are approximated based on what is known about the programs.

Table 4.19
Opportunity Cost Estimation of IPM Training Participants' Time

Method	**Duration of Training Method**	**Cost For Participation (Farmers' Daily Salary = US $1.00 per day)**
1. Agent/Dealer Visit	.5 days	US $ .50 per visit
2. Field Day Demonstration	1.0 day	US $1.00 demonstration day
3. FFS	.5 days per week X 14 weeks	US $7.00 per FFS program

The results of table 4.19 demonstrate that Farmer Field School participants incur the highest opportunity cost of $7.00 for participating. Field day demonstration participants and farmers visited by agents and dealers give up relatively little income by participating in these trainings.

IV.5 Cost-Effectiveness Results

The following section calculates the cost-effectiveness of IPM training methods at diffusing simple, intermediate and complex IPM practices to farmers. It incorporates the results from the previous sections in this chapter on cost and effectiveness of the different dissemination methods. The criteria from the effectiveness section that are included in the overall cost-effectiveness analysis are the method's ability to reach the greatest number of farmers with in a given budget, the method's ability to influence farmers to adopt IPM practices and the methods ability to influence farmers to use the practices appropriately. The cost-effectiveness analysis estimates the net benefit per farmer of extending various IPM technologies and practices through different methods. The technologies and practices that are used in the calculation are the simple practice of picking pests off of cabbage, the intermediate practice of using mustard oil cake in eggplant and the more complex technology of using bait traps in sweet gourds. These calculations provide insight into which methods are the most cost-effective at diffusing various technologies and practices to farmers.

IV.5.1 Cost Effectiveness of Simple Practices

The cost-effectiveness results for diffusing the simple practice of picking pests off of cabbage are presented in Tables 4.20, 4.21 and 4.22. Table 4.20 displays the benefits of adopting and using the pest picking practice appropriately on a per acre basis. The benefit per acre is calculated by using the formula in section III.4, where total revenue is calculated by subtracting the yield using the control practice of applying pesticides from the yield using the IPM practice. The difference between the two yields is multiplied by the price per ton of the crop to get an estimate of revenue. The difference between the cost of using the IPM practice and the cost of using the control practice is then subtracted from this change in revenue. Based upon this formula, the per acre benefit of using the pest picking practice is US $772.82.

Table 4.20
Benefit Per Acre of Picking Pests Off of Cabbage

Yield for Pest Picking (tons/acre)*	42.34
Yield for (control) Using Pesticides (tons/acre)*	35.57
Price for Cabbage (taka/ton) '	6,500
Cost for Pest Picking (taka/acre)*	14,431
Cost for (Control) Using pesticides (taka/acre)*	16,795
Benefit Per Acre (Bangladesh Taka) **Benefit Per Acre (US$)**	**46,369** **772.82**
Source: (*) IPM CRSP Trainer Manuel, 2003 (pg. 40) (') Bangladesh Bureau of Statistics 2001	

Table 4.21 presents the gross benefits of extending the pest picking practice through various methods. The study assumes that the average farmer has devoted .25 acres to cabbage cultivation. The percentage of appropriate users for each method is calculated by taking the percentage of farmers exposed to the practice that use it appropriately and determining by what methods the appropriate users had been trained. The percentage of appropriate users for the less intense field day method is determined by combining the appropriate users for the BARI field day and IPM CRSP field day. The percentage of appropriate users for the moderately intense agent visit is determined by combining the appropriate users for the DAE agent visits and the IPM CRSP visits. The percentage of appropriate users for the more intense FFS method is determined by combining the appropriate users for both the DAE FFS and the CARE FFS programs.

The first three columns in Table 4.21 are multiplied together in order to calculate a gross benefit per farmer of extending pest picking through a particular type of method. The results indicate that in the case of the simple pest picking practice, farmers trained through the more intense FFS method have the highest percentage for all methods of exposed farmers using the practice appropriately and thus the highest gross benefit per farmer trained of $50.23. The moderately intense visit method has the second highest percentage of exposed using pest picking appropriately and thus the second highest gross benefit per farmer of $48.30. The less intense field day method has the lowest percentage of exposed farmers using pest picking appropriately and thus the smallest gross benefit per farmer trained at $38.64.

Table 4.21
Benefit Per Farmer of Extending Pest Picking Practices Through Various Methods

	% of Exposed Farmers Using Practice Appropriately	Acres Under Cabbage Cultivation	Benefit Per Acre of Practice	Gross Benefit per Farmer
Less Intense Method (Field Day)	20%	0.25	$772.82	$38.64
Moderately Intense Method (Agent Visit)	25%	0.25	$772.82	$48.30
More Intense Method (FFS)	26%	0.25	$772.82	$50.23

The net benefit of the cost-effectiveness analysis for the simple pest picking practice in cabbage is calculated in Table 4.22. The net benefit for each method is calculated by subtracting the variable field costs, the opportunity cost of the trainers' time and the opportunity cost of participants' time from the gross benefit per farmer of each method. The value for the variable field cost of conducting field day demonstrations in Table 4.22 is the average of BARI field day cost and the IPM CRSP field day cost as described in section IV.4.1. The value for the variable field cost of the agent visit is based on the assumption that the agent spends $5.00 per month on travel and food and visits 10 farmers per month, as discussed in section IV.4.2. The variable field cost of conducting the FFS training is based on the field costs of establishing and conducting a village level FFS, as presented in Table 4.17 of section IV.4.3. The value for the opportunity cost of the trainers' time for field days is described in section IV.4.1. The value for the agents' opportunity cost is described in section IV.4.2 and the value of opportunity cost for the FFS trainers' time is described in section IV.4.3. The values for the opportunity costs to farmers who participate in the training methods are calculated in Table 4.19 of section IV.4.4.

The results for the net benefit of picking pests off of cabbage indicate that the moderately intense visit method is the most cost-effective at diffusing that practice to farmers with a net benefit of $44.70. Less intense field days are the second most cost-effective method with a net benefit of $32.47 while the more intense FFS method is the least cost-effective method at extending pest picking to farmers with a net benefit of $31.78. This estimation indicates that although FFS is found to have the highest gross benefit to farmers, when the cost of using FFS is considered it may be less desirable than other less intense and less expensive methods.

Table 4.22
Benefit and Costs of Extending Pest Picking in Cabbage Through Various Methods

	Gross Benefit of Each Method Per Farmer Trained	Variable Cost (Field Cost) Per Farmer	Per Farmer Opportunity Cost of Trainers' Time	Per Farmer Opportunity Cost of Participants' Time	Net Benefit Per Farmer
Less Intense Method (Field Day)	$38.64	$5.12	$0.05	$1.00	$32.47
Moderately Intense Method (Agent Visit)	$48.30	$0.50	$2.60	$0.50	$44.70
More Intense Method (FFS)	$50.23	$10.00	$1.45	$7.00	$31.78

IV.5.2 Cost-Effectiveness of Intermediate Practices

The results of estimating cost-effectiveness for an intermediate practice, using mustard oil cake in eggplant, are presented in Tables 4.23, 4.24 and 4.25. Table 4.23 calculates the per acre benefit of using mustard oil cake in eggplant. The estimate for the per acre benefit of using mustard oil cake is US $180.22.

Table 4.23
Benefit Per Acre of Using Mustard Oil Cake in Eggplant

Yield for Mustard Oil Cake (tons/acre)*	3.02
Yield for (Control) Using Insecticides (tons/acre)*	2.03
Price for Eggplant (Taka/ton) '	8,860
Cost for Mustard Oil Cake (taka/acre)*	16,149
Cost for (Control) Using insecticides (taka/acre)*	18,191
Benefit Per Acre (Taka) **Benefit Per Acre (US$)**	**10,813** **180.22**
Sources: (*) Alponi, 2003 (pg. 57) (') Bangladesh Bureau of Statistics 2001	

Table 4.24 presents the benefits of extending mustard oil cake information through various methods. The study assumes that the average farmer has devoted .5 acres to eggplant cultivation. The first three columns in Table 4.24 are multiplied together in order to calculate a gross benefit per farmer of extending the mustard oil cake practice through a particular method. The results indicate that in the case of mustard oil cake, less intense field day method creates a per farmer benefit of $37.85, while the more intense FFS creates a gross per farmer benefit of $31.54 and the moderately intense agent visit method creates a gross benefit of $27.03 per farmer.

Table 4.24
Benefit Per Farmer of Extending Mustard Oil Cake Practice Through Various Methods

	% of Exposed Farmers Using Practice Appropriately	Acres Eggplant Cultivation per Farm	Benefit Per Acre of Practice	Gross Benefit Per Farmer Trained
Less Intense Method (Field Day)	42%	0.5	180.22	37.85
Moderately Intense Method (Agent Visit)	30%	0.5	180.22	27.03
More Intense Method (FFS)	35%	0.5	180.22	31.54

The net benefit of the cost-effectiveness analysis for the intermediate practice of spreading mustard oil cake in eggplant is calculated in Table 4.25. The variable field cost, the trainers' opportunity cost and the participants' opportunity cost are all calculated by the same formula for the mustard oil cake practice as they are for the pest picking practice in the previous sub-section. The results of this estimation demonstrate that the less intense field day is the most cost-effective method for appropriately extending mustard oil cake, with a net benefit of $31.68. The moderately intense visit method is the second most cost-effective method with a per farmer net benefit of $23.43, while the more intense FFS method is the least cost-effective method for extending knowledge about mustard oil cake with a per farmer net benefit of $13.09.

Table 4.25
Benefit and Costs of Extending Mustard Oil Cake Practice Through Various Methods

	Benefit of Each Method Per Farmer Trained	Variable Cost (Field Cost) Per Farmer	Per Farmer Opportunity Cost of Trainers' Time	Per Farmer Opportunity Cost of Participants' Time	Net Benefit Per Farmer
Less Intense Method (Field Day)	$37.85	$5.12	$0.05	$1.00	$31.68
Moderately Intense Method (Agent Visit)	$27.03	$0.50	$2.60	$0.50	$23.43
More Intense Method (FFS)	$31.54	$10.00	$1.45	$7.00	$13.09

IV.5.3 Cost-Effectiveness of Complex Practices

The result of calculating the cost-effectiveness of a more complex practice of using bait traps for fruit flies in sweet gourds are presented in Table 4.26, 4.27 and 4.28. The benefit per acre of using bait traps is presented in Table 4.26. The estimate for the benefit per acre of using bait traps is US $331.45.

Table 4.26
Benefit Per Acre of Using Bait Traps in Sweet Gourd

Yield for Sweet Gourd (tons/acre)*	8.15
Yield for Control (tons/acre)*	4.94
Price for Sweet Gourd (Taka/ton) '	5,960
Cost for Sweet Gourd (taka/acre)*	8,134.27
Cost for Control (taka/acre)*	8,889.83
Benefit Per Acre (Taka) **Benefit Per Acre (US$)**	**19,887** **331.45**
Sources: (*) Islam, 2004 (pg. 53) (') Bangladesh Bureau of Statistics 2001	

Table 4.27 presents the gross benefit per farmer of extending bait traps through various methods. The study assumes that the average farmer has devoted .25 acres to sweet gourd cultivation. The first three columns in Table 4.27 are multiplied together in order to calculate a per farmer gross benefit of extending the bait trap technology through a particular method. The results of Table 4.27 demonstrate that the gross benefit per farmer of the less intense field day method is $24.03, while the per farmer gross benefit of the moderately intense method is $23.20 and the per farmer benefit of the more intense FFS method is $21.54.

Table 4.27
Benefit Per Farmer of Extending Bait Traps Through Various Methods

	% of Exposed Farmers Using Practice Appropriately	Average Area Under Sweet Gourd Cultivation	Benefit Per Acre Using Bait Traps	Gross Benefit of Each Method Per Farmer Trained
Less Intense Method (Field Day)	29%	0.25	331.45	$24.03
Moderately Intense Method (Agent Visit)	28%	0.25	331.45	$23.20
More Intense Method (FFS)	26%	0.25	331.45	$21.54

The net benefit of the cost-effectiveness analysis for the complex technology is calculated in Table 4.28. The per farmer net benefit of extending bait traps through various methods is calculated by subtracting the variable field costs, along with the trainers' and participants' opportunity cost from the gross benefit of that practice. The variable field costs, the opportunity cost of trainers' and participants' time are calculated in the same manner for the bait trap technology as they are for the pest picking and mustard oil cake practices The results of these calculations indicate that the moderately intense visit method is the most cost-effective mode of diffusing the bait traps technology to farmers with a net benefit of $19.60, while the less intense field day method is the second most cost-effective method with a net benefit of $17.86. The more intense FFS method is the least cost-effective of all three types creating a net benefit of only $3.09 per farmer.

Table 4.28
Benefit and Costs of Extending Bait Traps Through Various Methods

	Per Farmer Gross Benefit of Each Method	Variable Cost (Field Cost) Per Farmer	Opportunity Cost of Trainers' Time	Opportunity Cost of Participants' Time	Per Farmer Net Benefit
Less Intense Method (Field Day)	$24.03	$5.12	$0.05	$1.00	$17.86
Moderately Intense Method (Agent Visit)	$23.20	$0.50	$2.60	$0.50	$19.60
More Intense Method (FFS)	$21.54	$10.00	$1.45	$7.00	$3.09

IV.5.4 Conclusions

The cost-effectiveness calculations in section IV.5 present the net benefits of extending different IPM practices through various methods. The net benefit calculations for the IPM technologies of different complexity levels demonstrates that the moderately intense agent visit is the most cost-effective way to extend the simple pest picking practice in cabbage followed by the less intense field day method and then the more intense FFS method. In the case of the intermediate mustard oil cake in eggplant, field days are most cost-effective followed by agent visits and then FFS. For the complex bait trap practice, agent visits have been found to be the most cost-effective ahead of field days which is the second most cost-effective and FFS which is the least cost-effective.

This study indicates that while FFS may have a similar or sometimes even a slightly greater percentage of appropriate users than other methods, and thus a larger gross benefit, the higher costs associated with running FFS make it less cost-effective than field days or agent visits. Agent visits and field days are cost-effective methods for diffusing simple, intermediate and complex IPM technologies practices that can be used to compliment FFS or as substitutes for FFS when IPM practices are extended to farmers. This analysis is not a comprehensive calculation of cost and effectiveness as there are many components of effectiveness that may be considered and certain costs such as the fixed overhead costs were not included in the estimation. Furthermore FFS, agent visits and field days all have the ability to extend multiple practices to farmers so the total benefit of these methods is greater than the benefit of diffusing one technology. Regardless of the additional components that may be incorporated in this analysis, the estimation in this study provides insight into the most cost-effective methods at diffusing various technologies to farmers in Bangladesh.

Chapter V: Summary & Conclusions

V.1 Summary

The objective of this study is to evaluate the cost-effectiveness of different diffusion methods at extending various IPM practices and technologies to farmers in Bangladesh. Many resources are currently being allocated to disseminate IPM to farmers in Bangladesh, so determining how to extend new innovations in a cost-effective manner is essential for sustaining the IPM training programs. There are seven criteria used to measure the effectiveness of the IPM dissemination methods in this study. These criteria include reaching the greatest number of farmers within a given budget, spreading information quickly, and influencing adoption of IPM. Additional components of effectiveness include influencing appropriate use of IPM, influencing retention of information among participants, providing participants with the ability to transfer knowledge to various situations on the farm, and being accessible to limited resource farmers. Certain effectiveness criteria such as the method's ability to reach the greatest number of farmers within a given budget, the method's ability to influence the probability of adoption of IPM, and the method's ability to influence appropriate use of IPM practices are incorporated with the variable field costs and the opportunity costs of conducting the training in order to create an overall measurement of cost-effectiveness for the IPM diffusion methods.

Five hypotheses measuring effectiveness of IPM diffusion methods are tested in this study. The first hypothesis is that there is no significant difference in the probability of IPM adoption among farmers who have been trained through different methods. The results from the three ordered probit regression models in section IV.3.3 and Appendix B indicate that participants in the more intense FFS program and those who have received a moderately intense agent visit are significantly more likely to adopt a high number of simple IPM practices than participants in less intense field day and mass media programs. In the case of intermediate technologies, less intense field days, moderately intense agent visits and more intense FFS program are all found to be significant factors at influencing adoption of IPM. The results for complex technologies demonstrate that participants in less intense field days and more intense FFS are more likely to adopt complex practices than farmers who did not attend these programs. The first hypothesis in this study is rejected in the case of simple and complex practices as there is a significant difference in probability of adopting these practices among methods of different intensities. The first hypothesis is accepted in the case of intermediate practices, where there is no significant difference among methods at influencing their probability of adoption. One caveat to these results is that there may be endogeneity related to the factors that affect FFS participation. Endogeneity might result in overstating the impacts of FFS on participation because unobservable factors correlated with FFS participation may be also correlated with the probability of adopting IPM practices.

The second testable hypothesis in the study is that farmers trained through more intense methods are no more likely to use technology in an appropriate manner than farmers trained through less intense methods. The results from the probit models and descriptive charts in section IV.3.4 along with Appendix D indicate that the second hypothesis should not be rejected. In the case of the simple rice leaf clipping practice, there is no significant difference in probability of appropriate use among farmers who are exposed through less intense, moderately intense, and more intense methods. Figure 4.2 also demonstrates that a similar percentage of adopters trained by all the different methods use leaf clipping appropriately. In the case of the more complex bait trap practice, there is also no significant difference in the probability of appropriate use among farmers exposed through less intense, moderately intense, and more intense methods. Figure 4.3 indicates similar findings to Figure 4.2 that a similar percentage of adopter trained by all the different methods use bait traps appropriately.

The third testable hypothesis is that farmers trained through more intense methods have no higher retention rates than farmers trained through less intense methods. The results from section IV.3.5 indicate that most farmers in the sample were exposed to rice leaf clipping less than three years ago. Figure 4.4 shows that a higher percentage of adopters trained through field days and FFS who use rice leaf clipping appropriately, were trained three or more years ago compared with farmers trained less than three years ago. A higher percentage of farmers who received an agent visit, adopted rice leaf clipping and used it appropriately were trained less than three years ago compared to those trained three or more years ago. The results in Figure 4.5 for the more complex bait traps show that more farmers were exposed to the technology less than three years ago than those that were exposed three or more years ago. Figure 4.5 demonstrates that higher percentages of adopters who use bait traps appropriately were exposed less than three years ago, among those farmers trained through all of the different methods. Figure 4.5 gives a slight indication that farmers may not retain information about bait traps over time regardless of how they were trained.

The regression results in Table 4.7 indicate that there is no significant difference in appropriate use between farmers who were exposed to simple rice leaf clipping less than three years ago and those who learned about the practice three or more years ago. The regression results in Table 4.8 for the more complex bait trap practice show that the THREEORMORE variable has a negative coefficient, but the variable is not significant. The results of the regression in this section do not allow the third hypothesis to be rejected.

The fourth testable hypothesis is that farmers who learn about a technology through intense methods are no more likely to adapt the knowledge to other situations on their farm than farmers trained through any other method. The results from section IV.3.6 and Appendix E demonstrate that less intense methods such as field days, moderately intense methods such as visits, and more intense methods such as FFS are all fairly highly correlated with the probability of discovery through experimentation. Only the VISIT variable is significant in the probit regression model measuring discovery through experimentation. Results from this section indicate that the fourth hypothesis may be rejected because farmers who receive an agent visit seem to be statistically more likely to apply their knowledge to other situations on their farm than farmers trained through other methods.

The fifth testable hypothesis is that less intense methods do not provide significantly greater access to limited resource farmers than do any other methods. Results from Figure 4.6 in section IV.3.7 demonstrate that marginal/landless and small farmers are well represented and make up a significant percentage of the participants in the various training programs. This result is understandable because most farmers in Bangladesh are small or marginal farmers. The results of this section indicate however that a high percentage of the large farmers in the sample have received agent visits and been to farmer field schools. The descriptive statistics from this section do not provide enough evidence to reject the fifth hypothesis because farmers of limited resources appear to have access to all of the IPM training programs including FFS.

Findings for the analysis of informal diffusion of IPM practices indicate that respondents in villages with FFS mention hearing about IPM practices from informal sources significantly less than farmers in villages without FFS. These results may be caused by farmers in FFS villages hearing about IPM more through formal methods, (FFS and otherwise) or by farmers in non-FFS villages relying on informal information sources more than farmers in FFS villages. These findings may also be caused by various social factors in the village or because other methods such as agent visits and field days, that have occurred in the non-FFS village may be more effective than FFS at influencing informal diffusion of Information.

The regression results examining informal diffusion indicate that FFS trained farmers are aware of significantly more simple, intermediate, and complex practices than farmers in their village who did not attend FFS and farmers in other villages that have not had FFS. This result is not surprising as one would expect FFS to expose farmers to many IPM practices. It appears that farmers in the FFS villages who did not attend FFS know about significantly more simple IPM practices than farmers living in villages with no FFS. This result may indicate that FFS trained farmers share information on simple practice with other farmers in their villages. Conversely, farmers in the non-FFS village know about significantly more intermediate IPM practices than farmers living in the FFS villages who did not attend the FFS. Furthermore, there is no significant difference in awareness of complex practices between farmers in the non-FFS villages and farmers in the FFS village who did not attend FFS. Farmers in the villages with no FFS have learned about IPM from other less intense sources such as agents and field days. It seems that farmers who have attended FFS are not spreading a greater number of intermediate and complex practices throughout their villages than training programs operating in non-FFS villages such as agents, and field days, are at transferring information on IPM practices to other farmers. FFS graduates failure to share intermediate and complex practices with others may be due to the complexity of the innovations and the time that is required to explain them to others.

Results of the cost-effectiveness estimation in section IV.5 indicate that for simple practice, moderately intense agent visits are the most cost-effective method for extending the practice, followed by the less intense field day method. The more intense FFS method is found to be the least cost-effective way to extend simple practices. The less intense field day is the most cost-effective method for diffusing intermediate practices. Moderately intense agent visit is the second most cost-effective method and the FFS method is the least cost-effective method at diffusing intermediate practices. For the more complex practices the moderately intense agent visit is found to be most cost-effective, followed by the less intense field day demonstration. The more intense FFS method is the least cost-effective method. The results from section IV.5 show that agent visits and field days are more cost-effective than FFS due to their relatively lower costs and nearly equal rate of adoption and appropriate use.

V.2 Extensions and Limitations

This study could be improved by collecting a larger sample size than the 350 farmers interviewed for this study. The small sample size makes some aspects of the analysis difficult due to the wide variety of methods and information sources that contributed to farmers learning about IPM. The low R^2 in some of the regression models can be attributed to small sample size and the numerous sources of IPM information. Data were collected during the rainy monsoon season in Bangladesh, which physically limited the enumerators from being able to speak with farmers in certain places. Some cost data, such as the expenses for the CARE FFS was not available for the study so the cost of the CARE FFS was assumed to be equal to the cost of the DAE FFS. It was not clear for some of the data used in measuring yield whether the measurements were in metric tons per acre or in standard tons per acre.

This study could be extended by returning to Bangladesh in the future to collect additional data from the respondents about their use of IPM practices and technologies. These additional data would allow for a time series analysis to be conducted in order to evaluate adoption, appropriate use and retention of IPM practices and technologies over a period of years. Additional investigation could be conducted on the effects of participating in a combination of training methods such as attending both an FFS and a field day. This study attempted to analyze the effectiveness of utilizing multiple methods to extend IPM information, however measuring joint effects of using two or more methods was difficult to quantify with this data set due to the limited sample size and the numerous sources where farmers learn about IPM. Further research could also be conducted concerning the role that farmers' informal information networks have on influencing farmers to adopt and use IPM technologies and practices appropriately.

V.3 Conclusions & Policy Implications

Significant resources are being spent to train Bangladeshi farmers on IPM. The government of Bangladesh is currently undertaking an expensive initiative to train 20% of the pesticide using house-holds in Bangladesh, using farmer field schools as the principal dissemination method. The budget for this project is US $40 million over the next ten years, so consideration should be given to the cost-effectiveness of implementing such a program. This study indicates that while FFS may be effective in certain situations or according to certain criteria, such as influencing adoption, there are alternative methods such as field days and agent visits that in some instances may be more cost-effective than FFS.

The following recommendations, based on the findings from this study may be useful to policy makers in Bangladesh who are interested in extending IPM to farmers.

- Farmer Field School participation is found to significantly influence adoption of IPM but other less intense and less expensive methods such as field days and agent visits are also found to influence adoption of certain types of technologies. Field days and agent visits are found to be less expensive than FFS and should be considered as potential vehicles for extending IPM because in many situations they are more cost-effective than FFS. For example, both field days and agent visits are found to be more cost-effective than FFS at diffusing simple, intermediate, and complex IPM practices and technologies.

- Mass media is currently underutilized in Bangladesh. Newspapers, bulletins and radio could be used to extend information quickly and reach a large number of farmers per dollar spent.

- Field days can be used to introduce new IPM practices and technologies. Field days provide farmers with first hand exposure to IPM and like mass media allow many farmers to be trained per dollar spent.

- The study finds that farmers who are involved in community organizations are more likely to adopt IPM practices. Therefore community organizations should be encouraged.

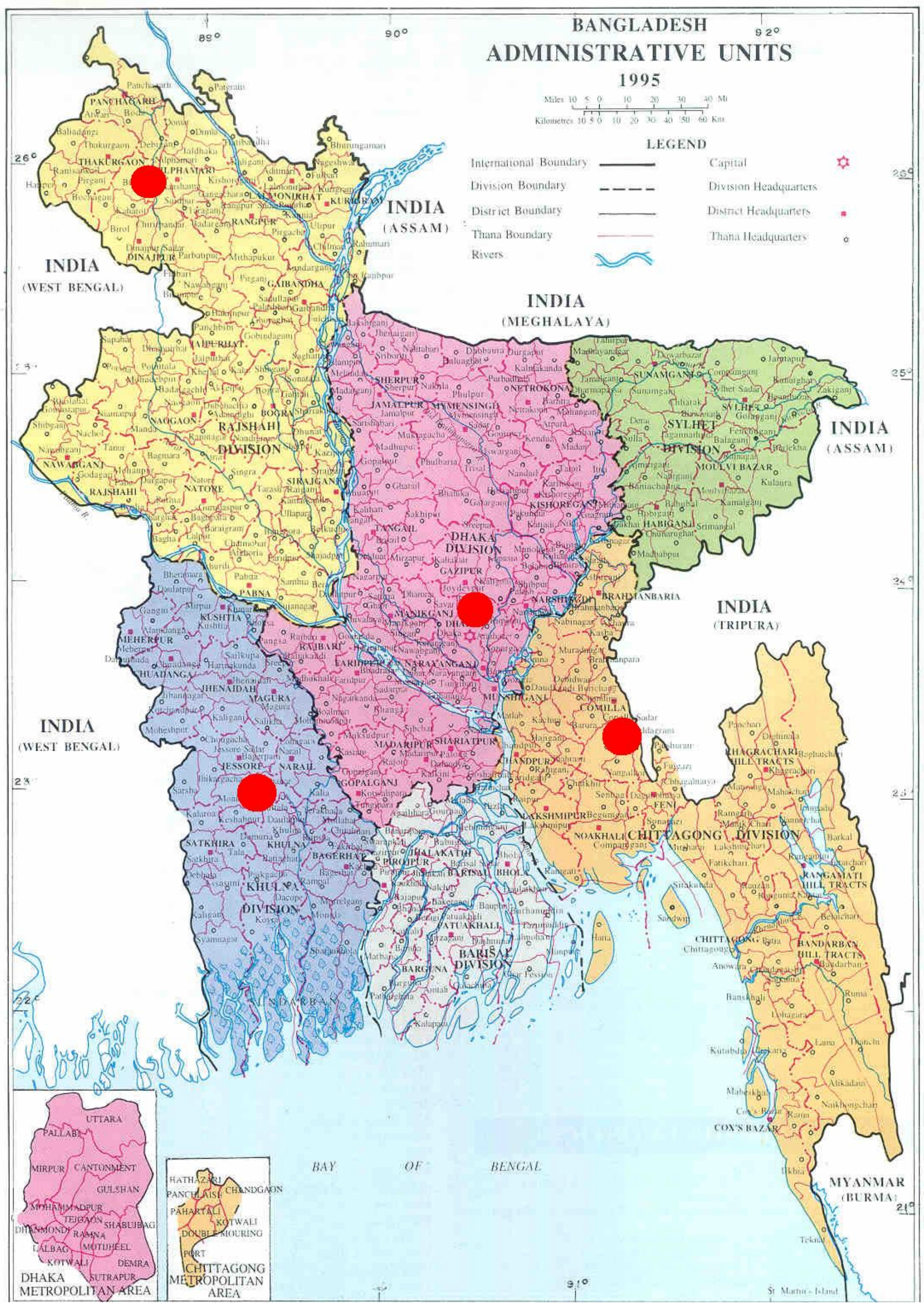
- Since only 20% of house-holds in Bangladesh will receive formal training in the new IPM initiative, informal diffusion of information among farmers at the local level is essential for ensuring that the remaining 80% of house-holds have access to IPM knowledge. Informal diffusion of IPM information seems to be occurring among people in villages with FFS for simple practices. However farmers who participated in FFS appear to be no better at extending intermediate and complex practices to others than are field days, and agent visits that take place in the villages with no FFS. Policy makers should not rely only on FFS graduates to diffuse intermediate and complex practices to non-FFS participants in their villages because the practices may be difficult to understand and take time to explain. Other less intense methods such as agent visits or field days can be used to support the information provided during FFS and extend it to a greater number of farmers.

Policy makers could use a combination of training methods utilize each program's individual advantages and use them to complement one another. For example mass media could be used in combination with farmer field schools to diffuse IPM practices and technologies to a large number of people more cost-effectively than using only FFS. Field days could also be used in areas where FFS has previously been conducted to reinforce the IPM concepts and expand the knowledge to a wider audience.

This study should not be interpreted as supporting one IPM diffusion method as being better than another method but rather it shows that a particular method may be more cost-effective than other methods at diffusing certain IPM technologies to farmers. Results from this study can help guide future policy decisions not only in Bangladesh but in other countries that plan to implement IPM policy at the national level.

MAP OF BANGLADESH & STUDY AREAS

Denotes Study Area



(Source: Bangladeshgov.org)

APPENDIX A: SURVEY

COST EFFECTIVE DIFFUSION OF IPM TECHNOLOGIES IN BANGLADESH

TYPE OF RESPONDENT – FFS GRAD Rice / FFS Grad Vegetable / Non FFS farmer

General Information **Questionnaire No. _________**

Sex: M F

Age _____________________________ **Number of Family members in household __________**

Respondent's Name: _________________________ **Experience farming (yrs) ___________**

Village _____________________________________ **Union ___________________________**

Thana ______________________________________ **District _________________________**

Interviewer _________________________________ **Date of Interview _________________**

1. How many farm families live in this village? _______

2. How many farm families do you think use IPM technology?
A) On Rice? __________ **B)** On Vegetables? _____________

3. What is your level of literacy?
_____ 1) Illiterate _____ 4) HSC
_____ 2) Can write name _____ 5) Degree
_____ 3) Primary level _____ 6) Advanced degree

4. How many trainings on IPM have you received in your lifetime? _________ (If None go to Q. 7)

5. What type of IPM training did you receive?
_____ 1) Visit/Meeting with DAE personnel
_____ 2) Demonstration/Field Day
_____ 3) Farmer field school for rice
_____ 4) Farmer field school for vegetables
_____ 5) IPM Club
_____ 6) Other (specify ________________)

6. How many years ago did you receive IPM training?

A) RICE
____ 1) 0 to 1 yr
____ 2) 1 to 2 yr
____ 3) 2 to 5 yr
____ 4) 5 to 10 yr
____ 5) more than 10 yr

B) VEGETABLES
____ 1) 0 to 1 yr
____ 2) 1 to 2 yr
____ 3) 2 to 5 yr
____ 4) 5 to 10 yr
____ 5) more than 10 yr

SIMPLE TECHNOLOGY

No.	**Technology**	**Crop**	**Knows** *Yes =1, No = 2*	**Uses** *Yes =1, No = 2*	**Source (use code)**	**Years ago learned (use code)**
7.	Are you aware of varieties of rice and eggplant that are resistant to pests?	Rice	*(If no go to No.8)*			

		Eggplant	*(If no go to No.8)*			

No.	Technology	Crop	Knows *Yes =1, No = 2*	Uses *Yes =1, No = 2*	Source (use code)	Years ago learned (use code)
8.	Are you aware that some farmers use hand nets to sweep pests off of their rice	Rice	*(If no go to No. 9)*			
9.	Are you aware of placing branches in your rice field on which birds can perch?	Rice	*(If no go to No. 10)*			
10.	Are you aware that pest infestation in cabbage may be controlled by hand picking insects off of the leaves?	Cabbage	*(If no go to No.12)*			

11. How many days after transplanting do you begin handpicking pests off of cabbage? *(Recom: 2 weeks)*

_____ 1) Start after 1 week
_____ 2) Start after 2 weeks
_____ 3) Start after 3 weeks

Code:
Sources*: (may mark more then one)*

1 = Newspaper/leaflet/bulletin **2** = TV/Radio **3** = Demonstration/field day
4 = Farmer field school **5** = DAE personnel **6** = Relative
7 = Neighbor **8** = Pesticide dealer **9** = IPM club
9 = Other (specify ---)

Years ago: **1** = 0 to 1 year ago **2** = 1 to 2 year ago **3** = 2 to 5 year ago
4 = 5 to 10 year ago **5** = more then 10 year ago

INTERMEDIATE TECHNOLOGIES

(If they do not grow cabbage go to No. 15)
12. How many times per season do you weed your cabbage? *(Recom: two times)*

_____ 1) 1 time (Go to Q. 15)
_____ 2) 2 times (Go to Q. 13)
_____ 3) 3 times (Go to Q. 15)
_____ 4) 4 or more times (Go to Q. 15)

13. What source recommended that you weed your cabbage twice per season? *(Mark all that apply)*

_____ 1) newspaper/leaflet /bulletin
_____ 2) radio/TV
_____ 3) demonstration/field day
_____ 4) Farmer field school
_____ 5) DAE personnel
_____ 6) relative
_____ 7) neighbor
_____ 8) pesticide dealer
_____ 9) IPM club
_____ 10) other (specify_______________________________)

14. How many years ago did that source make this recommendation?

_____ 1) 0 to 1 yr
_____ 2) 1 to 2 yr
_____ 3) 3 to 5 yr
_____ 4) 5 to 10 yr
_____ 5) more than 10 yr

No.	**Technology**	**Crop**	**Aware** *Yes =1, No = 2*	**Uses** *Yes =1, No = 2*	**Source (use code)**	**Years ago learned (use code)**
15.	Are you aware that you can reduce pest infestation in rice by clipping the infected leaves on the plant?	Rice	*(if no go to No. 17)*			
16.	How many days after transplanting did you clip rice leaves? *(Recom: 60 to 70 days after transplanting)* _____1) 30 days _____ 3) 60 days _____2) 45 days _____ 4) 75 days					
17.	Are you aware that by covering the soil with white polyethylene sheet you can heat up the soil and kill pests in your seed beds?	Rice	*(if no go to No. 19)*			
		Vegetable	*(if no go to No. 19)*			
18.	How many weeks before seed sowing did you apply the sun solarization? *(Recom: around 3 weeks)* _____1) 1 week _____ 3) 3 weeks _____2) 2 weeks _____ 4) 4 weeks					
19.	Are you aware of burning sawdust in your vegetable bed to kill pests in the soil?	Vegetable	*(if no go to No. 21)*			
20.	How thick do you make the layer of sawdust before burning? *(Recom: around 6 cm thick)* _____1) 1 inch _____ 3) 2 inch _____ 5) 3 inch _____2) 1.5 inch _____ 4) 2.5 inch _____ 6) 3.5 inch					
21.	Are you aware that the soil can be enriched by adding poultry refuse?	Vegetable	*(if no go to No. 23)*			
22.	Do you irrigate after applying the poultry refuse? *(Recom: yes)* _____ 1) Yes _____ 2) No					
23.	Are you aware that the soil can be enriched and pests may be killed by adding mustard/Neem oil cake?	Vegetable	*(if no go to No. 25)*			
24.	How many weeks before seed sowing do you apply mustard/neem oil cake? *(Recom: around 2 weeks)* _____ 1) 1 week _____ 3) 3 weeks _____ 2) 2 weeks _____ 4) 4 weeks					
25.	Are you aware that traps of mashed sweet gourd bait may be used to capture fruit flies in your cucurbitae and gourd crop?	Cucur-bitae & Gourd	*(if no go to No. 27)*			

26.	How often should you change the bait traps? *(Recom: every three days/ twice a week)* _____ 1) once a week _____ 3) once every other week _____ 2) twice a week _____ 4) once every month					
27.	Are you aware that pheromone bait traps Are being used to capture fruit flies in cucurbitae and gourd crops?	Cucur-bitae & Gourd	*(if no go to No. 29)*			
28.	How often should you change pheromone traps? *(Recom: every three months)* _____ 1) every month _____ 3) every 3 months _____ 2) every 2 months _____ 4) every 4 months					

29. Technology (Spraying)
How many times during the growing season do you apply insecticides in your rice crop?
_____ 1) more then 40 times
_____ 2) between 30-40 times
_____ 3) between 20-30 times
_____ 4) between 10-20 times
_____ 5) between 1-10 times
_____ 6) do not spray/only spray as last alternative (Go to Q. 31)

30. How many days after transplanting do you make your first spray? ___________

31. Did you ever receive information from any of the following source(s) that influenced your decision of when and how many times to spray? *(Mark all that apply)*
_____ 1) newspaper/leaflet /bulletin
_____ 2) radio/TV
_____ 3) demonstration/field day
_____ 4) Farmer field school
_____ 5) DAE personnel
_____ 6) relative
_____ 7) neighbor
_____ 8) pesticide dealer
_____ 9) IPM club
_____ 10) other (specify_____________________)

32. How many years ago did you hear information about spraying from that/those source(s)?
_____ 1) 0 to 1 yr
_____ 2) 1 to 2 yr
_____ 3) 3 to 5 yr
_____ 4) 5 to 10 yr
_____ 5) more than 10 yr

COMPLEX TECHNOLOGIES

33. Are you aware that eggplant seedlings may be grafted with wild solanum root stocks to make them more resistant to bacterial wilt?
_____ 1) Yes
_____ 2) No (Go to Q. 38)

34. Do you graft these eggplant seedlings yourself or purchase them from someone else?
_____ 1) Graft them myself
_____ 2) Purchase grafted seedlings
_____ 3) Do not use grafted seedlings (Go to Q. 36)

35. When using a grafted eggplant seedling with a wild solanum root stock, should the united part of the two grafted seedlings be placed above or below the soil? *(Recom: above the soil)*
_____ 1) above the soil

_____ 2) below the soil

36. Where did you learn about grafted eggplants? *(Mark all that apply)*

_____ 1) newspaper/leaflet /bulletin
_____ 2) radio/TV
_____ 3) demonstration/field day
_____ 4) Farmer field school
_____ 5) DAE personnel
_____ 6) relative
_____ 7) neighbor
_____ 8) pesticide dealer
_____ 9) IPM club
_____ 10) other (specify______________________)

37. How long ago did you hear information about grafted eggplants from that/those source(s)?

_____ 1) 0 to 1 yr
_____ 2) 1 to 2 yr
_____ 3) 3 to 5 yr
_____ 4) 5 to 10 yr
_____ 5) more than 10 yr

38. Beneficial Insects

Are all insects harmful to crops?

_____ 1) Yes (Go to Q. 43) _____ 2) No

No.	**Technology**	**Crop**	**Aware** *Yes =1, No = 2*	**Uses** *Yes =1, No = 2*	**Source (use code)**	**Years ago learned (use code)**
39.	Are you aware of beneficial insects?	Rice	*(if no go to No. 43)*			
		Vegetables	*(if no go to No. 43)*			

40. What do beneficial insects do?

_____ 1) kill harmful insects
_____ 2) nothing/don't know

41. Have you reduced your spraying of pesticides in rice and vegetables since learning about beneficial insects?

A) Rice _____ 1) Yes
_____ 2) No

B) Vegetables _____ 1)Yes
_____ 2) No

(If no for both rice and vegetables go to Q. 43)

42. If yes by how many sprayings have you reduced pesticide use?

A) on rice
_____ 1) reduced by more then 20
_____ 2) reduced by 15-20
_____ 3) reduced by 10-15
_____ 4) reduced by 5-10
_____ 5) reduced by 0-5

B) on vegetables
_____ 1) reduced by more than 20
_____ 2) reduced by 15-0
_____ 3) reduced by 1015
_____ 4) reduced by 5-10
_____ 5) reduced by 0-5

Please state whether you agree, disagree, or have no opinion about the following statements

Statement	I agree	I disagree	I don't know/ no opinion
43) We should spray insecticides as much as possible to ensure a good crop yield			
44) There are alternatives to using pesticides			
45) Some pesticides are harmful to humans			
46) Insecticides are like medicine, they make the plants healthier			
47) Some insects kill other insects			
48) Protective clothing should be worn when applying pesticides			
49) Some pesticides damage the environment			
50) Pesticides should be used only as a last option			

Organizational Participation of the Farmer

51) Are you engaged in any social organizations in your community?

_____ 1) Yes
_____ 2) No (Go to Q. 53)

52) If yes, please mention you involvement in the following organizations.

Organization	**Executive Officer *(3)***	**No. Years Involved**	**Executive Member *(2)***	**No. Years Involved**	**General Member *(1)***	**No. Years Involved**	**No involve-ment *(0)***
Village Society							
Farmers' Cooperative Society							
Union Parishad							
Adult Education Committee							
Youth Development Society							
Political Party							
NGO							
School Committee							
Mosque Committee							
Market Committee							
Other Organization (Specify)							

Farmer's Travel

53) Do you travel outside of your local area (i.e. Upazila, District or City)?

_____ 1) Yes
_____ 2) No (Go to Q. 55)

54) If yes, Mention how often you travel outside of you local area?

Area Traveled	**Frequently (3)**	**Sometimes (2)**	**Seldom (1)**	**Never (0)**
Neighboring Village	15 ≥ days/ month	8-14 days/month	1-7 days/month	

Different Upazila	10 ≥ days/ month	6-9 days/month	1-5 days/month	
Different District	5 ≥ days/ month	3-4 days/month	1-2 days/month	
Foreign Country	3 ≥ times / life	2 times / life	1 time / life	

55) Are you involved in any of the following activities mentioned below?

Activity	Yes or No (If yes then check)	Years of Involvement
1. Green manuring		
2. Use of compost fertilizer		
3. Use of Isles for crop production		
4. Use of IPM techniques		
5. Produce fish in the rice field		
6. Other (specify ________________)		

56) Extension Contact: How often do you have contact with the following people?

Type of Media	Regularly (4)	Frequently (3)	Sometimes (2)	Seldom (1)	Never (0)
1. Block supervisor	8 ≥ times/month	5-7 times/month	3-4 times/month	1-2 times/month	
2. Agriculture officer	12 ≥ times/year	7-11 times/year	3-6 times/year	1-2 times/year	
3. Local leader	10 ≥ times/month	6-9 times/month	3-5 times/month	1-2 times/month	
4. Neighboring farmer	15 ≥ times/month	10-14 times/month	5-9 times/month	1-4 times/month	
5. Agricultural fair	8 ≥ times/lifetime	5-7 times/lifetime	3-4 times/lifetime	1-2 times/lifetime	
6. Agricultural radio program	5 ≥ times/month	3-4 times/month	2-3 times/month	1 time/month	
7. Agricultural TV program	5 ≥ times/month	3-4 times/month	2-3 times/month	1 time/month	
8. Block demonstration	5 ≥ times/year	3-4 times/year	2 times/year	1 time/year	
9. Read agricultural publication	12 ≥ days/year	7-11 days/year	3-6 days/year	1-2 days/year	
10. Read newspaper	15 ≥ days/month	10-14 days/month	5-9 days/month	1-4 days/month	
11. Travel to research institutions	8≥ times/lifetime	5-7 times/lifetime	3-4 times/lifetime	1-2 times/lifetime	
12. Attend field day	8≥ times/lifetime	5-7 times/lifetime	3-4 times/lifetime	1-2 times/lifetime	

57) Awareness of collecting seeds: Do you collect seeds from any of the following sources?

Sources	BADC (5)	Authorized Sale Center (4)	Own Seed (3)	Neighboring Farmer (2)	Open Market (1)
1. Rice seed					
2. Vegetable seed					

58) Who influenced you to adopt IPM technology and how much were you influenced?

Person	Very high (4)	High (3)	Low (2)	Very low (1)	No influence (0)
1. Family member					
2. Neighbor					
3. Block supervisor					
4. Agricultural officer					
5. Scientist					
6. NGO official					

59) Farm size/Land Tenure (in decimal) ***100 decimal = 1 acre***

Land Category	Amount of land	Land Category	Amount of Land
1. Own cultivated land		6. Homestead	
2. Rented in land		7. Orchard	
3. Rented out land		8. Bamboo garden	
4. Mortgaged in land		9. Pond	
5. Mortgaged out land			

{Farm size = 1 + 2 + 4 + 6 + 7 + 8 + 9 – 3 – 5}

60) Household annual income (last year's income)

Source	Amount (Tk/yr)	Source	Amount (Tk/yr)
1. Agriculture		2. Livestock	
Aus rice		Cow/Goat sale	
Aman rice		Poultry/Egg sale	
Boro rice		Milk sale	
Potato		3. Business	
Vegetable		4. Service	
Pulses		5. Fisheries	
Oil seeds		6. Fruit	
Wheat		7. Other	
Sugarcane			

61) If necessary is there anywhere that you can borrow money?

_____ 1) Yes
_____ 2) No (Go to Q. 63)

62) If yes, from what source do you borrow money?

_____ 1) Bank _____ 4) Money lender
_____ 2) Relative _____ 5) Friend
_____ 3) Cooperative _____ 6) Other (Specify _____________)

63) How many kilometers is your farm from the nearest market? _______________

Thank you for your time. Your participation is greatly appreciated!

Appendix B: Marginal Effects for Adoption Models

B.1
Marginal Effects for Adoption of Simple IPM Technologies and Practices

Table B.1.1
Marginal Effects when simple score = 0

```
. mfx compute, predict (outcome(0))
Marginal effects after oprobit
     y  = Pr(simplescore==0) (predict, outcome(0))
        =  .01289684
```

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.00027	0.01259	0.983	-0.02495	0.024399	0.022857
FDAY*	-0.00344	0.00549	0.531	-0.0142	0.007317	0.108571
VISIT*	-0.00805	0.00564	0.153	-0.0191	0.002997	0.691429
FFS*	-0.04587	0.01374	0.001	-0.0728	-0.01894	0.508571
AGE	-0.00136	0.00087	0.118	-0.00307	0.000348	37.4629
AGESQ	1.58E-05	0.00001	0.125	-4.40E-06	0.000036	1563.06
FAM	-0.00093	0.00085	0.277	-0.0026	0.000747	6.28235
MALE*	0.005868	0.00558	0.293	-0.00507	0.016804	0.931429
PRIM*	-0.00287	0.00456	0.53	-0.0118	0.006071	0.242857
HSSC	-0.00689	0.0041	0.093	-0.01491	0.001143	0.382857
DEG*	-0.00066	0.00567	0.907	-0.01177	0.010449	0.148571
ORG*	-0.01717	0.00739	0.02	-0.03165	-0.00268	0.614286
FARMSIZE	1.21E-05	0.00001	0.116	-3.00E-06	0.000027	254.294
MARK	-0.00066	0.00166	0.694	-0.00392	0.002607	1.602
JESSORE*	0.015381	0.00857	0.073	-0.00141	0.032171	0.305714
COMILLA*	-0.01011	0.00525	0.054	-0.02041	0.000186	0.24
NILPHA~I*	-0.0022	0.01049	0.834	-0.02276	0.018362	0.028571
THAKUR~N*	0.021529	0.01456	0.139	-0.00702	0.050075	0.134286

Table B.1.2
Marginal Effects when simple score = 1

Mfx	compute,	predict	(outcome(1))
Marginal	effects	after	oprobit
Y	=	Pr(simplescore==1)	(predict, outcome(1))
	=	0.184183	

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.00202	0.09362	0.983	-0.18552	0.181466	0.022857
FDAY*	-0.02702	0.04497	0.548	-0.11516	0.061131	0.108571
VISIT*	-0.05487	0.03273	0.094	-0.11902	0.009285	0.691429
FFS*	-0.26304	0.03482	0	-0.33129	-0.1948	0.508571
AGE	-0.01001	0.00569	0.078	-0.02116	0.001135	37.4629
AGESQ	0.000116	0.00007	0.085	-1.6E-05	0.000248	1563.06
FAM	-0.00682	0.00601	0.256	-0.01859	0.004958	6.28235
MALE*	0.049351	0.05118	0.335	-0.05097	0.149666	0.931429
PRIM*	-0.02181	0.03544	0.538	-0.09127	0.047652	0.242857
HSSC	-0.05058	0.02624	0.054	-0.10201	0.000843	0.382857
DEG*	-0.00491	0.04263	0.908	-0.08846	0.07865	0.148571
ORG*	-0.11196	0.03293	0.001	-0.1765	-0.04742	0.614286
FARMSIZE	0.000089	0.00005	0.076	-9.30E-06	0.000187	254.294
MARK	-0.00481	0.01216	0.692	-0.02864	0.019012	1.602
JESSORE*	0.097647	0.04162	0.019	0.016066	0.179227	0.305714
COMILLA*	-0.08381	0.03751	0.025	-0.15734	-0.01028	0.24
NILPHA~I*	-0.017	0.08508	0.842	-0.18374	0.149749	0.028571
THAKUR~N*	0.117748	0.05646	0.037	0.007083	0.228412	0.134286

Table B.1.3
Marginal Effects when simple score = 2

Mfx	compute,	predict	(outcome(2))	
Marginal	effects	after	oprobit	
Y	=	Pr(simplescore==2)	(predict,	outcome(2))
	=	0.292846		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.00102	0.04745	0.983	-0.09401	0.091977	0.022857
FDAY*	-0.01494	0.02766	0.589	-0.06915	0.039265	0.108571
VISIT*	-0.02431	0.01344	0.071	-0.05066	0.002037	0.691429
FFS*	-0.11622	0.02306	0	-0.16142	-0.07101	0.508571
AGE	-0.00497	0.00279	0.075	-0.01044	0.000496	37.4629
AGESQ	5.76E-05	0.00003	0.082	-7.40E-06	0.000123	1563.06
FAM	-0.00339	0.003	0.259	-0.00927	0.002498	6.28235
MALE*	0.030367	0.03822	0.427	-0.04455	0.105284	0.931429
PRIM*	-0.01147	0.01973	0.561	-0.05014	0.027197	0.242857
HSSC	-0.02513	0.01355	0.064	-0.05169	0.001433	0.382857
DEG*	-0.00248	0.02193	0.91	-0.04546	0.040495	0.148571
ORG*	-0.04783	0.01466	0.001	-0.07657	-0.0191	0.614286
FARMSIZE	4.42E-05	0.00003	0.089	-6.70E-06	0.000095	254.294
MARK	-0.00239	0.00604	0.692	-0.01422	0.009441	1.602
JESSORE*	0.039134	0.01473	0.008	0.010259	0.068009	0.305714
COMILLA*	-0.05149	0.02847	0.071	-0.10729	0.004315	0.24
NILPHA~I*	-0.00916	0.04966	0.854	-0.1065	0.088173	0.028571
THAKUR~N*	0.035057	0.01109	0.002	0.013313	0.056801	0.134286

Table B.1.4
Marginal Effects when simple score = 3

Mfx	compute,	predict	(outcome(3))	
Marginal	effects	after	oprobit	
Y	=	Pr(simplescore==3)	(predict,	outcome(3))
	=	0.338295		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.001189	0.05475	0.983	-0.10612	0.108496	0.022857
FDAY*	0.0151	0.02364	0.523	-0.03123	0.061433	0.108571
VISIT*	0.033635	0.02104	0.11	-0.0076	0.074869	0.691429
FFS*	0.14355	0.02638	0	0.091849	0.19525	0.508571
AGE	0.005906	0.0033	0.073	-0.00056	0.01237	37.4629
AGESQ	-6.8E-05	0.00004	0.081	-0.00015	8.40E-06	1563.06
FAM	0.004022	0.00356	0.259	-0.00296	0.011001	6.28235
MALE*	-0.02564	0.02255	0.256	-0.06984	0.018568	0.931429
PRIM*	0.01252	0.01986	0.528	-0.0264	0.051442	0.242857
HSSC	0.029837	0.01585	0.06	-0.00122	0.060894	0.382857
DEG*	0.002871	0.02475	0.908	-0.04563	0.051372	0.148571
ORG*	0.068521	0.02264	0.002	0.024152	0.112889	0.614286
FARMSIZE	-5.3E-05	0.00003	0.085	-0.00011	7.30E-06	254.294
MARK	0.00284	0.00716	0.692	-0.0112	0.016883	1.602
JESSORE*	-0.0612	0.02787	0.028	-0.11582	-0.00658	0.305714
COMILLA*	0.043031	0.01753	0.014	0.008679	0.077382	0.24
NILPHA~I*	0.009639	0.04621	0.835	-0.08093	0.100206	0.028571
THAKUR~N*	-0.07832	0.04118	0.057	-0.15903	0.00239	0.134286

Table B.1.5
Marginal Effects when simple score = 4

Mfx	compute,	predict	(outcome(4))	
Marginal	effects	after	oprobit	
Y	=	Pr(simplescore==4)	(predict,	outcome(4))
	=	0.142447		

Variable	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
Mmedia*	0.001566	0.07278	0.983	-0.14108	0.144216	0.022857
Fday*	0.022003	0.03898	0.572	-0.05439	0.0984	0.108571
Visit*	0.040017	0.02284	0.08	-0.00475	0.084785	0.691429
Ffs*	0.198278	0.02913	0	0.141177	0.255378	0.508571
Age	0.007705	0.00443	0.082	-0.00098	0.016391	37.4629
Agesq	-8.9E-05	0.00005	0.089	-0.00019	0.000014	1563.06
Fam	0.005247	0.00463	0.257	-0.00382	0.014315	6.28235
Male*	-0.0427	0.04982	0.391	-0.14036	0.054952	0.931429
Prim*	0.017287	0.0288	0.548	-0.03916	0.073738	0.242857
Hssc	0.038927	0.02052	0.058	-0.0013	0.079148	0.382857
Deg*	0.003809	0.03339	0.909	-0.06163	0.069251	0.148571
Org*	0.080728	0.02305	0	0.035554	0.125902	0.614286
Farmsize	-6.9E-05	0.00004	0.079	-0.00015	7.90E-06	254.294
Mark	0.003705	0.00936	0.692	-0.01465	0.022056	1.602
Jessore*	-0.06836	0.02719	0.012	-0.12164	-0.01507	0.305714
Comilla*	0.07258	0.03701	0.05	0.000043	0.145116	0.24
Nilpha~i*	0.01365	0.0714	0.848	-0.1263	0.153599	0.028571
Thakur~n*	-0.0739	0.02984	0.013	-0.13239	-0.0154	0.134286

Table B.1.6
Marginal Effects when simple score = 5

Mfx	mfx compute,	(outcome(5))	
Marginal	Marginal effects	oprobit	
Y	= y	(predict,	Outcome(5))
	= 0.029332		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.000559	0.02612	0.983	-0.05064	0.051758	0.022857
FDAY*	0.008297	0.01556	0.594	-0.02219	0.038788	0.108571
VISIT*	0.01358	0.00785	0.084	-0.00181	0.028969	0.691429
FFS*	0.083306	0.01926	0	0.045553	0.121058	0.508571
AGE	0.002738	0.00165	0.097	-0.00049	0.005969	37.4629
AGESQ	-3.2E-05	0.00002	0.104	-0.00007	6.50E-06	1563.06
FAM	0.001864	0.00168	0.269	-0.00144	0.005166	6.28235
MALE*	-0.01725	0.02285	0.45	-0.06203	0.027536	0.931429
PRIM*	0.006337	0.01102	0.565	-0.01526	0.027931	0.242857
HSSC	0.013831	0.00761	0.069	-0.00109	0.028748	0.382857
DEG*	0.001366	0.0121	0.91	-0.02235	0.025077	0.148571
ORG*	0.027714	0.0094	0.003	0.009289	0.04614	0.614286
FARMSIZE	-2.4E-05	0.00001	0.093	-5.3E-05	4.00E-06	254.294
MARK	0.001316	0.00333	0.693	-0.00522	0.007849	1.602
JESSORE*	-0.02261	0.00946	0.017	-0.04116	-0.00406	0.305714
COMILLA*	0.0298	0.01773	0.093	-0.00496	0.064559	0.24
NILPHA~I*	0.005067	0.02765	0.855	-0.04912	0.059253	0.028571
THAKUR~N*	-0.02212	0.00872	0.011	-0.03922	-0.00502	0.134286

TABLE B.2
Marginal Effects for Adoption of Intermediate Technologies and Practices

Table B.2.1
Marginal Effects when intermediate score =0

```
Mfx compute, predict (outcome(0))
Marginal effects after oprobit
     y  = Pr(intermediatescore==0) (predict, outcome(0))
        =  .02692315
```

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.017	0.035	0.622	-0.051	0.085	0.023
FDAY*	-0.023	0.008	0.003	-0.038	-0.008	0.109
VISIT*	-0.022	0.011	0.041	-0.043	-0.001	0.691
FFS*	-0.052	0.015	0.000	-0.080	-0.023	0.509
AGE	0.001	0.001	0.386	-0.002	0.004	37.463
AGESQ	0.000	0.000	0.266	0.000	0.000	1563.060
FAM	-0.001	0.002	0.585	-0.004	0.002	6.282
MALE*	-0.001	0.015	0.966	-0.030	0.029	0.931
PRIM*	-0.013	0.008	0.106	-0.028	0.003	0.243
HSSC	-0.005	0.006	0.386	-0.018	0.007	0.383
DEG*	-0.008	0.009	0.371	-0.026	0.010	0.149
ORG*	-0.027	0.011	0.014	-0.048	-0.005	0.614
FARMSIZE	0.000	0.000	0.580	0.000	0.000	254.294
MARK	0.009	0.004	0.011	0.002	0.016	1.602
JESSORE*	0.034	0.015	0.029	0.003	0.064	0.306
COMILLA*	0.058	0.024	0.014	0.012	0.104	0.240
NILPHA~I*	-0.015	0.013	0.239	-0.040	0.010	0.029
THAKUR~N*	0.053	0.027	0.054	-0.001	0.106	0.134

Table B.2.2
Marginal Effects when intermediate score = 1

```
. mfx compute, predict (outcome(1))
Marginal effects after oprobit
Y =
Pr(intermediatescore==1)        (predict,    outcome(1))
  =  0.129
```

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.042	0.074	0.570	-0.104	0.188	0.023
FDAY*	-0.081	0.024	0.001	-0.128	-0.034	0.109
VISIT*	-0.058	0.024	0.018	-0.106	-0.010	0.691
FFS*	-0.134	0.026	0.000	-0.185	-0.084	0.509
AGE	0.004	0.004	0.384	-0.004	0.011	37.463
AGESQ	0.000	0.000	0.259	0.000	0.000	1563.060
FAM	-0.002	0.004	0.584	-0.011	0.006	6.282
MALE*	-0.002	0.042	0.966	-0.085	0.081	0.931
PRIM*	-0.039	0.024	0.104	-0.086	0.008	0.243
HSSC	-0.016	0.018	0.377	-0.050	0.019	0.383
DEG*	-0.024	0.028	0.388	-0.079	0.031	0.149
ORG*	-0.071	0.024	0.003	-0.118	-0.024	0.614
FARMSIZE	0.000	0.000	0.577	0.000	0.000	254.294
MARK	0.026	0.009	0.005	0.008	0.044	1.602
JESSORE*	0.084	0.030	0.006	0.024	0.143	0.306
COMILLA*	0.125	0.037	0.001	0.053	0.197	0.240
NILPHA~I*	-0.050	0.048	0.301	-0.145	0.045	0.029
THAKUR~N*	0.110	0.042	0.009	0.028	0.192	0.134

Table B.2.3
Marginal Effects when intermediate score = 2

Mfx	compute,	predict	(outcome(2))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==2)	(predict,	outcome(2))
	=	0.277		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.030	0.041	0.467	-0.050	0.109	0.023
FDAY*	-0.097	0.037	0.009	-0.170	-0.025	0.109
VISIT*	-0.044	0.017	0.009	-0.078	-0.011	0.691
FFS*	-0.111	0.022	0.000	-0.154	-0.067	0.509
AGE	0.003	0.004	0.384	-0.004	0.010	37.463
AGESQ	0.000	0.000	0.261	0.000	0.000	1563.060
FAM	-0.002	0.004	0.584	-0.009	0.005	6.282
MALE*	-0.002	0.036	0.965	-0.072	0.069	0.931
PRIM*	-0.037	0.025	0.139	-0.087	0.012	0.243
HSSC	-0.014	0.015	0.377	-0.044	0.017	0.383
DEG*	-0.023	0.029	0.427	-0.080	0.034	0.149
ORG*	-0.056	0.018	0.002	-0.091	-0.021	0.614
FARMSIZE	0.000	0.000	0.577	0.000	0.000	254.294
MARK	0.023	0.008	0.006	0.007	0.039	1.602
JESSORE*	0.060	0.019	0.002	0.023	0.098	0.306
COMILLA*	0.074	0.017	0.000	0.040	0.108	0.240
NILPHA~I*	-0.055	0.067	0.409	-0.187	0.076	0.029
THAKUR~N*	0.060	0.015	0.000	0.031	0.089	0.134

Table B.2.4
Marginal Effects when intermediate score = 3

Mfx	compute,	predict	(outcome(3))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==3)	(predict,	outcome(3))
	=	0.278		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.017	0.038	0.650	-0.093	0.058	0.023
FDAY*	-0.003	0.015	0.847	-0.031	0.026	0.109
VISIT*	0.021	0.011	0.069	-0.002	0.043	0.691
FFS*	0.039	0.014	0.006	0.011	0.066	0.509
AGE	-0.001	0.001	0.404	-0.003	0.001	37.463
AGESQ	0.000	0.000	0.291	0.000	0.000	1563.060
FAM	0.001	0.001	0.590	-0.002	0.003	6.282
MALE*	0.001	0.013	0.966	-0.025	0.026	0.931
PRIM*	0.008	0.005	0.090	-0.001	0.018	0.243
HSSC	0.005	0.005	0.390	-0.006	0.015	0.383
DEG*	0.006	0.005	0.268	-0.004	0.015	0.149
ORG*	0.024	0.011	0.030	0.002	0.046	0.614
FARMSIZE	0.000	0.000	0.582	0.000	0.000	254.294
MARK	-0.008	0.004	0.038	-0.015	0.000	1.602
JESSORE*	-0.033	0.016	0.037	-0.063	-0.002	0.306
COMILLA*	-0.058	0.023	0.012	-0.103	-0.013	0.240
NILPHA~I*	0.004	0.012	0.739	-0.019	0.027	0.029
THAKUR~N*	-0.055	0.028	0.048	-0.110	0.000	0.134

Table B.2.5
Marginal Effects when intermediate score = 4

Mfx	compute,	predict	(outcome(4))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==4)	(predict,	outcome(4))
	=	0.148		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.027	0.046	0.557	-0.118	0.064	0.023
FDAY*	0.054	0.016	0.001	0.022	0.085	0.109
VISIT*	0.038	0.016	0.017	0.007	0.069	0.691
FFS*	0.087	0.018	0.000	0.051	0.122	0.509
AGE	-0.002	0.003	0.384	-0.008	0.003	37.463
AGESQ	0.000	0.000	0.261	0.000	0.000	1563.060
FAM	0.002	0.003	0.584	-0.004	0.007	6.282
MALE*	0.001	0.028	0.966	-0.054	0.056	0.931
PRIM*	0.026	0.016	0.110	-0.006	0.058	0.243
HSSC	0.010	0.012	0.380	-0.013	0.034	0.383
DEG*	0.016	0.019	0.394	-0.021	0.054	0.149
ORG*	0.046	0.016	0.003	0.015	0.077	0.614
FARMSIZE	0.000	0.000	0.577	0.000	0.000	254.294
MARK	-0.017	0.006	0.006	-0.030	-0.005	1.602
JESSORE*	-0.054	0.020	0.006	-0.093	-0.015	0.306
COMILLA*	-0.078	0.022	0.000	-0.122	-0.034	0.240
NILPHA~I*	0.034	0.033	0.299	-0.030	0.098	0.029
THAKUR~N*	-0.068	0.024	0.005	-0.115	-0.020	0.134

Table B.2.6
Marginal Effects when intermediate score = 5

Mfx	compute,	predict	(outcome(5))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==5)	(predict,	outcome(5))
	=	0.078		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.021	0.033	0.520	-0.085	0.043	0.023
FDAY*	0.058	0.022	0.009	0.014	0.102	0.109
VISIT*	0.030	0.012	0.014	0.006	0.055	0.691
FFS*	0.075	0.017	0.000	0.042	0.108	0.509
AGE	-0.002	0.002	0.384	-0.006	0.002	37.463
AGESQ	0.000	0.000	0.261	0.000	0.000	1563.060
FAM	0.001	0.002	0.584	-0.003	0.006	6.282
MALE*	0.001	0.024	0.966	-0.046	0.048	0.931
PRIM*	0.024	0.016	0.135	-0.007	0.055	0.243
HSSC	0.009	0.010	0.382	-0.011	0.029	0.383
DEG*	0.015	0.018	0.419	-0.021	0.050	0.149
ORG*	0.038	0.013	0.003	0.013	0.063	0.614
FARMSIZE	0.000	0.000	0.578	0.000	0.000	254.294
MARK	-0.015	0.005	0.006	-0.025	-0.004	1.602
JESSORE*	-0.043	0.015	0.005	-0.073	-0.013	0.306
COMILLA*	-0.058	0.016	0.000	-0.090	-0.026	0.240
NILPHA~I*	0.034	0.039	0.391	-0.043	0.111	0.029
THAKUR~N*	-0.049	0.016	0.003	-0.081	-0.017	0.134

Table B.2.7
Marginal Effects when intermediate score = 6

Mfx	compute,	predict	(outcome(6))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==6)	(predict,	outcome(6))
	=	0.036		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.012	0.018	0.495	-0.047	0.023	0.023
FDAY*	0.042	0.019	0.027	0.005	0.079	0.109
VISIT*	0.018	0.008	0.019	0.003	0.033	0.691
FFS*	0.047	0.013	0.000	0.022	0.073	0.509
AGE	-0.001	0.001	0.391	-0.004	0.002	37.463
AGESQ	0.000	0.000	0.271	0.000	0.000	1563.060
FAM	0.001	0.002	0.586	-0.002	0.004	6.282
MALE*	0.001	0.015	0.965	-0.028	0.029	0.931
PRIM*	0.015	0.011	0.162	-0.006	0.036	0.243
HSSC	0.005	0.006	0.386	-0.007	0.018	0.383
DEG*	0.009	0.012	0.437	-0.014	0.033	0.149
ORG*	0.023	0.009	0.008	0.006	0.040	0.614
FARMSIZE	0.000	0.000	0.580	0.000	0.000	254.294
MARK	-0.009	0.004	0.013	-0.016	-0.002	1.602
JESSORE*	-0.025	0.010	0.008	-0.044	-0.007	0.306
COMILLA*	-0.033	0.010	0.001	-0.054	-0.013	0.240
NILPHA~I*	0.023	0.030	0.440	-0.036	0.082	0.029
THAKUR~N*	-0.027	0.010	0.004	-0.046	-0.009	0.134

Table B.2.8
Marginal Effects when intermediate score = 7

Mfx	compute,	predict	(outcome(7))	
Marginal	effects	after	oprobit	
Y	=	Pr(intermediatescore==7)	(predict,	outcome(7))
	=	0.017		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.007	0.009	0.476	-0.025	0.012	0.023
FDAY*	0.028	0.015	0.061	-0.001	0.057	0.109
VISIT*	0.010	0.005	0.037	0.001	0.020	0.691
FFS*	0.029	0.010	0.004	0.009	0.048	0.509
AGE	-0.001	0.001	0.400	-0.002	0.001	37.463
AGESQ	0.000	0.000	0.286	0.000	0.000	1563.060
FAM	0.000	0.001	0.588	-0.001	0.002	6.282
MALE*	0.000	0.008	0.965	-0.016	0.017	0.931
PRIM*	0.009	0.007	0.191	-0.005	0.023	0.243
HSSC	0.003	0.004	0.391	-0.004	0.010	0.383
DEG*	0.006	0.007	0.452	-0.009	0.020	0.149
ORG*	0.013	0.006	0.023	0.002	0.025	0.614
FARMSIZE	0.000	0.000	0.581	0.000	0.000	254.294
MARK	-0.005	0.002	0.032	-0.010	0.000	1.602
JESSORE*	-0.014	0.006	0.020	-0.026	-0.002	0.306
COMILLA*	-0.018	0.007	0.009	-0.032	-0.005	0.240
NILPHA~I*	0.015	0.021	0.476	-0.026	0.055	0.029
THAKUR~N*	-0.015	0.006	0.013	-0.026	-0.003	0.134

B.2.9
Marginal Effects when intermediate score = 8

Mfx	compute,	predict	(outcome(8))	
Marginal	effects	After	oprobit	
Y	=	Pr(intermediatescore==8)	(predict,	outcome(8))
	=	0.009		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.004	0.006	0.453	-0.015	0.007	0.023
FDAY*	0.022	0.014	0.116	-0.006	0.051	0.109
VISIT*	0.007	0.004	0.070	-0.001	0.014	0.691
FFS*	0.020	0.009	0.019	0.003	0.037	0.509
AGE	0.000	0.001	0.410	-0.002	0.001	37.463
AGESQ	0.000	0.000	0.302	0.000	0.000	1563.060
FAM	0.000	0.001	0.593	-0.001	0.001	6.282
MALE*	0.000	0.006	0.965	-0.011	0.011	0.931
PRIM*	0.006	0.005	0.219	-0.004	0.017	0.243
HSSC	0.002	0.002	0.394	-0.003	0.007	0.383
DEG*	0.004	0.005	0.473	-0.007	0.014	0.149
ORG*	0.009	0.004	0.047	0.000	0.017	0.614
FARMSIZE	0.000	0.000	0.584	0.000	0.000	254.294
MARK	-0.004	0.002	0.057	-0.007	0.000	1.602
JESSORE*	-0.009	0.005	0.045	-0.018	0.000	0.306
COMILLA*	-0.011	0.005	0.030	-0.022	-0.001	0.240
NILPHA~I*	0.011	0.017	0.517	-0.022	0.044	0.029
THAKUR~N*	-0.009	0.004	0.036	-0.017	-0.001	0.134

TABLE B.3
Marginal Effects for Adoption of Complex Technologies and Practices

B.3.1
Marginal Effects when complex score = 0

```
. mfx compute, predict (outcome(0))
Marginal effects after oprobit
     y  = Pr(complexscore==0) (predict, outcome(0))
        =  .39512286
```

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.211	0.200	0.291	-0.181	0.602	0.023
FDAY*	-0.254	0.061	0.000	-0.373	-0.134	0.109
VISIT*	-0.047	0.055	0.399	-0.155	0.062	0.691
FFS*	-0.434	0.050	0.000	-0.531	-0.337	0.509
AGE	-0.030	0.012	0.012	-0.053	-0.007	37.463
AGESQ	0.000	0.000	0.026	0.000	0.001	1563.060
FAM	-0.003	0.011	0.756	-0.024	0.018	6.282
MALE*	0.071	0.097	0.463	-0.119	0.261	0.931
PRIM*	0.052	0.065	0.422	-0.075	0.180	0.243
HSSC	-0.032	0.040	0.430	-0.111	0.047	0.383
DEG*	0.016	0.073	0.828	-0.128	0.160	0.149
ORG*	-0.130	0.054	0.017	-0.236	-0.023	0.614
FARMSIZE	0.000	0.000	0.693	0.000	0.000	254.294
MARK	-0.012	0.021	0.570	-0.053	0.029	1.602
JESSORE*	0.502	0.059	0.000	0.387	0.617	0.306
COMILLA*	0.280	0.075	0.000	0.132	0.427	0.240
NILPHA~I*	0.365	0.128	0.004	0.114	0.617	0.029
THAKUR~N*	0.497	0.065	0.000	0.369	0.625	0.134

Table B.3.2
Marginal Effects when complex score = 1

```
. mfx compute, predict (outcome(1))
Marginal effects after oprobit
     y  = Pr(complexscore==1) (predict, outcome(1))
        =  .28639283
```

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.048	0.073	0.514	-0.192	0.096	0.023
FDAY*	-0.037	0.028	0.194	-0.093	0.019	0.109
VISIT*	0.004	0.006	0.502	-0.008	0.016	0.691
FFS*	0.031	0.019	0.102	-0.006	0.068	0.509
AGE	0.002	0.002	0.203	-0.001	0.006	37.463
AGESQ	0.000	0.000	0.219	0.000	0.000	1563.060
FAM	0.000	0.001	0.761	-0.001	0.002	6.282
MALE*	-0.001	0.006	0.844	-0.012	0.010	0.931
PRIM*	-0.005	0.008	0.535	-0.021	0.011	0.243
HSSC	0.002	0.003	0.487	-0.004	0.009	0.383
DEG*	-0.001	0.007	0.846	-0.015	0.012	0.149
ORG*	0.013	0.009	0.159	-0.005	0.031	0.614
FARMSIZE	0.000	0.000	0.702	0.000	0.000	254.294
MARK	0.001	0.002	0.594	-0.002	0.004	1.602
JESSORE*	-0.104	0.027	0.000	-0.157	-0.050	0.306
COMILLA*	-0.052	0.025	0.035	-0.100	-0.004	0.240
NILPHA~I*	-0.116	0.069	0.094	-0.251	0.020	0.029
THAKUR~N*	-0.158	0.039	0.000	-0.234	-0.081	0.134

Table B.3.3
Marginal Effects when complex score = 2

Mfx	compute,	predict	(outcome(2))	
Marginal	effects	after	Oprobit	
Y	=	Pr(complexscore==2)	(predict,	outcome(2))
	=	0.306		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.152	0.122	0.213	-0.392	0.087	0.023
FDAY*	0.241	0.065	0.000	0.114	0.368	0.109
VISIT*	0.039	0.045	0.394	-0.050	0.127	0.691
FFS*	0.355	0.043	0.000	0.271	0.440	0.509
AGE	0.025	0.010	0.012	0.006	0.045	37.463
AGESQ	0.000	0.000	0.026	-0.001	0.000	1563.060
FAM	0.003	0.009	0.756	-0.015	0.021	6.282
MALE*	-0.062	0.089	0.481	-0.236	0.111	0.931
PRIM*	-0.043	0.053	0.414	-0.147	0.060	0.243
HSSC	0.027	0.034	0.430	-0.040	0.093	0.383
DEG*	-0.013	0.061	0.826	-0.132	0.106	0.149
ORG*	0.107	0.044	0.015	0.020	0.193	0.614
FARMSIZE	0.000	0.000	0.693	0.000	0.000	254.294
MARK	0.010	0.018	0.570	-0.025	0.045	1.602
JESSORE*	-0.364	0.043	0.000	-0.448	-0.280	0.306
COMILLA*	-0.211	0.052	0.000	-0.313	-0.108	0.240
NILPHA~I*	-0.236	0.062	0.000	-0.358	-0.115	0.029
THAKUR~N*	-0.319	0.038	0.000	-0.392	-0.245	0.134

Table B.3.4
Marginal Effects when complex score = 3

Mfx	compute,	predict	(outcome(3))	
Marginal	effects	after	Oprobit	
Y	=	Pr(complexscore==3)	(predict,	outcome(3))
	=	0.013		

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.010	0.006	0.088	-0.022	0.002	0.023
FDAY*	0.050	0.026	0.055	-0.001	0.100	0.109
VISIT*	0.004	0.004	0.388	-0.005	0.012	0.691
FFS*	0.047	0.014	0.001	0.019	0.075	0.509
AGE	0.003	0.001	0.043	0.000	0.005	37.463
AGESQ	0.000	0.000	0.062	0.000	0.000	1563.060
FAM	0.000	0.001	0.758	-0.002	0.002	6.282
MALE*	-0.008	0.013	0.555	-0.033	0.018	0.931
PRIM*	-0.004	0.005	0.397	-0.014	0.005	0.243
HSSC	0.003	0.004	0.443	-0.004	0.010	0.383
DEG*	-0.001	0.006	0.822	-0.013	0.010	0.149
ORG*	0.010	0.005	0.043	0.000	0.021	0.614
FARMSIZE	0.000	0.000	0.695	0.000	0.000	254.294
MARK	0.001	0.002	0.576	-0.003	0.005	1.602
JESSORE*	-0.034	0.011	0.001	-0.055	-0.013	0.306
COMILLA*	-0.017	0.006	0.007	-0.029	-0.005	0.240
NILPHA~I*	-0.013	0.005	0.007	-0.023	-0.004	0.029
THAKUR~N*	-0.020	0.007	0.003	-0.034	-0.007	0.134

Appendix C: Procedure to Correct for Endogeneity of FFS Participation

TABLE C.1
Probit for selection into FFS

probit ffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Probit estimates			Number of obs	=	350.000
			LR chi2(14)	=	73.490
			Prob > chi2	=	0.000
Log likelihood	= -205.807		Pseudo R2	=	0.152

FFS	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
AGE	0.030	0.037	0.415	-0.042	0.103
AGESQ	-0.001	0.000	0.178	-0.002	0.000
FAM	-0.037	0.032	0.251	-0.101	0.026
MALE	-1.254***	0.368	0.001	-1.976	-0.532
PRIM	-0.069	0.189	0.714	-0.440	0.301
HSSC	0.185	0.127	0.146	-0.064	0.435
DEG	0.111	0.220	0.615	-0.321	0.543
ORG	0.398**	0.156	0.011	0.091	0.704
FARMSIZE	0.001**	0.000	0.021	0.000	0.001
MARK	0.068	0.065	0.297	-0.059	0.195
JESSORE	0.228	0.190	0.230	-0.145	0.601
COMILLA	0.957***	0.217	0.000	0.532	1.383
NILPHAMARI	0.681	0.461	0.140	-0.223	1.585
THAKURGION	0.380	0.249	0.128	-0.109	0.868
_CONS	0.308	0.794	0.698	-1.248	1.864

Single, double, and triple asterisk indicate corresponding coefficients in the probit model are significant at the 10%, 5% and 1% level respectively.

Generate *phat*, *inverse mill's ratio* and *pffs.*

```
. predict phat, xb

. gen mills =  exp(-.5*phat^2) /
(sqrt(2*_pi)*normprob(phat))


 predict pffs
(option p assumed; Pr(ffs))
```

TABLE C.2
Ordered Probit Measuring Simple Score for FFS Participants

oprobit simplescore mills attendffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit	estimates		Number of obs	=	178.000
			LR chi2(15)	=	63.730
			Prob > chi2	=	0.000
Log likelihood	-230.554		Pseudo R2	=	0.121
Simplescore	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
Mills	1.107	1.424	0.437	-1.684	3.898
Age	0.201***	0.054	0.000	0.095	0.307
Agesq	-0.003***	0.001	0.001	-0.004	-0.001
Fam	-0.044	0.044	0.316	-0.130	0.042
Male	-0.860	0.851	0.312	-2.527	0.808
Prim	-0.226	0.258	0.381	-0.731	0.280
Hssc	0.396	0.247	0.109	-0.089	0.880
Deg	-0.271	0.290	0.349	-0.839	0.297
Org	0.447	0.388	0.249	-0.313	1.207
Farmsize	0.000	0.001	0.805	-0.001	0.001
Mark	0.105	0.091	0.248	-0.074	0.284
Jessore	0.335	0.339	0.322	-0.329	0.999
Comilla	1.867**	0.827	0.024	0.246	3.487
Nilphamari	1.561**	0.727	0.032	0.135	2.986
Thakurgion	0.069	0.467	0.883	-0.846	0.984
_cut1	2.763	1.517		(Ancillary	parameters)
_cut2	3.718	1.522			
_cut3	4.946	1.532			
_cut4	5.949	1.545			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

TABLE C.3
Ordered Probit Model Measuring Simple Score while Correcting for Endogeneity of FFS Participation

oprobit simplescore mmedia fday visit pffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit estimates				Number of obs	= 350
				LR chi2(18)	= 92.40
				Prob > chi2	= 0.00
Log likelihood = -527.60099				Pseudo R2	= 0.0805
SIMPLESCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MMEDIA	0.146	0.381	0.702	-0.602	0.893
FDAY	-0.126	0.193	0.514	-0.503	0.252
VISIT	0.200	0.126	0.111	-0.046	0.446
PFFS	2.429	1.881	0.197	-1.259	6.116
AGE	0.028	0.024	0.245	-0.019	0.075
AGESQ	0.000	0.000	0.562	-0.001	0.001
FAM	0.038	0.032	0.227	-0.024	0.101
MALE	0.348	0.729	0.634	-1.081	1.776
PRIM	0.138	0.161	0.389	-0.176	0.453
HSSC	0.122	0.149	0.412	-0.169	0.413
DEG	-0.034	0.185	0.856	-0.397	0.329
ORG	0.194	0.296	0.513	-0.387	0.775
FARMSIZE	-0.001	0.000	0.165	-0.002	0.000
MARK	-0.017	0.067	0.803	-0.147	0.114
JESSORE	-0.424*	0.225	0.060	-0.866	0.018
COMILLA	-0.115	0.654	0.860	-1.397	1.167
NILPHAMARI	-0.227	0.562	0.686	-1.327	0.874
THAKURGION	-0.581*	0.325	0.074	-1.218	0.056
_cut1	0.425	1.316		(Ancillary	parameters)
_cut2	1.661	1.317			
_cut3	2.376	1.319			
_cut4	3.247	1.321			
_cut5	4.124	1.325			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

TABLE C.4
Ordered Probit Measuring Intermediate score for FFS Participants

oprobit intermediatescore mills attendffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit	estimates		Number of obs	=	178.000
			LR chi2(15)	=	33.470
			Prob > chi2	=	0.004
Log likelihood	-320.649		Pseudo R2	=	0.050
INTERMEDIATE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MILLS	-0.316	1.361	0.816	-2.984	2.352
AGE	0.082	0.051	0.104	-0.017	0.181
AGESQ	-0.001	0.001	0.253	-0.002	0.001
FAM	-0.015	0.042	0.730	-0.097	0.068
MALE	0.048	0.808	0.952	-1.535	1.631
PRIM	0.504**	0.240	0.036	0.033	0.976
HSSC	0.170	0.207	0.412	-0.235	0.575
DEG	0.009	0.261	0.973	-0.502	0.520
ORG	-0.148	0.371	0.689	-0.875	0.578
FARMSIZE	0.000	0.001	0.979	-0.001	0.001
MARK	-0.058	0.087	0.505	-0.228	0.112
JESSORE	-0.395	0.324	0.223	-1.030	0.240
COMILLA	-0.315	0.786	0.688	-1.856	1.225
NILPHAMARI	1.207*	0.684	0.078	-0.134	2.549
THAKURGION	-0.676	0.448	0.131	-1.555	0.202
_cut1	-1.116	1.442		(Ancillary	parameters)
_cut2	-0.161	1.431			
_cut3	0.586	1.432			
_cut4	1.366	1.433			
_cut5	1.879	1.434			
_cut6	2.459	1.438			
_cut7	3.031	1.447			
_cut8	3.651	1.465			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

TABLE C.5
Ordered Probit Model Measuring Intermediate Score while Correcting for Endogeneity of FFS Participation

oprobit Intermediatescore mmedia fday visit pffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit estimates				Number of obs =	350
				LR chi2(18) =	55.25
				Prob > chi2 =	0.0000
Log likelihood = -639.65757				Pseudo R2 =	0.0414
INTERMEDIATSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
MMEDIA	-0.115	0.373	0.757	-0.846	0.615
FDAY	0.355*	0.186	0.057	-0.011	0.720
VISIT	0.296**	0.124	0.017	0.053	0.540
PFFS	1.741	1.842	0.344	-1.868	5.351
AGE	-0.025	0.024	0.295	-0.071	0.022
AGESQ	0.000	0.000	0.217	0.000	0.001
FAM	0.022	0.031	0.480	-0.039	0.083
MALE	0.400	0.713	0.574	-0.996	1.797
PRIM	0.261*	0.157	0.096	-0.046	0.569
HSSC	0.037	0.143	0.793	-0.242	0.317
DEG	0.099	0.181	0.585	-0.255	0.453
ORG	0.222	0.290	0.445	-0.348	0.791
FARMSIZE	0.000	0.000	0.464	-0.001	0.001
MARK	-0.163**	0.066	0.013	-0.292	-0.034
JESSORE	-0.483**	0.221	0.029	-0.917	-0.049
COMILLA	-0.935	0.642	0.145	-2.193	0.322
NILPHAMARI	0.095	0.546	0.862	-0.975	1.165
THAKURGION	-0.666**	0.320	0.037	-1.293	-0.039
_cut1	-0.999	1.289		(Ancillary	parameters)
_cut2	-0.128	1.286			
_cut3	0.662	1.286			
_cut4	1.342	1.287			
_cut5	1.835	1.289			
_cut6	2.276	1.291			
_cut7	2.676	1.293			
_cut8	3.105	1.298			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

TABLE C.6
Ordered Probit Measuring Complex score for FFS Participants

oprobit Complexscore mills attendffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit estimates				Number of obs	= 178
				LR chi2(15)	= 52.63
				Prob > chi2	= 0.0000
Log likelihood = -183.11202				Pseudo R2	= 0.1257
COMPLEXSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
Mills	2.394	1.540	0.120	-0.625	5.412
Age	0.084	0.056	0.132	-0.025	0.193
Agesq	-0.001	0.001	0.133	-0.003	0.000
Fam	-0.038	0.047	0.413	-0.130	0.054
Male	-1.476	0.919	0.108	-3.277	0.324
Prim	-0.291	0.261	0.264	-0.802	0.220
Hssc	0.074	0.222	0.738	-0.361	0.509
Deg	-0.178	0.282	0.527	-0.731	0.374
Org	0.797*	0.418	0.057	-0.023	1.617
Farmsize	0.001	0.001	0.156	0.000	0.002
Mark	0.092	0.097	0.338	-0.097	0.282
Jessore	-1.137***	0.369	0.002	-1.859	-0.414
Comilla	0.762	0.889	0.391	-0.980	2.505
Nilphamari	0.483	0.764	0.527	-1.014	1.979
Thakurgion	-0.941*	0.503	0.061	-1.927	0.044
_cut1	0.942	1.578		(Ancillary	parameters)
_cut2	1.917	1.582			
_cut3	3.976	1.606			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

TABLE C.7
Ordered Probit Model Measuring Complex Score While Correcting for Endogeneity of FFS Participants

oprobit complexscore mmedia fday visit pffs age agesq fam male prim hssc deg org farmsize mark jessore comilla nilphamari thakurgion

Ordered probit	estimates		Number of obs	=	350.000
			LR chi2(18)	=	80.300
			Prob > chi2	=	0.000
Log likelihood	-376.096		Pseudo R2	=	0.097
COMPLEXSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
Mmedia	-0.266	0.468	0.570	-1.183	0.651
Fday	0.378*	0.210	0.073	-0.035	0.790
Visit	0.124	0.138	0.369	-0.147	0.394
Pffs	-1.422	2.265	0.530	-5.861	3.016
Age	0.083**	0.035	0.017	0.015	0.151
Agesq	-0.001**	0.001	0.038	-0.002	0.000
Fam	-0.021	0.036	0.555	-0.091	0.049
Male	-1.059	0.875	0.226	-2.774	0.656
Prim	-0.182	0.179	0.307	-0.533	0.168
Hssc	0.212	0.165	0.199	-0.111	0.535
Deg	0.022	0.199	0.914	-0.368	0.411
Org	0.644*	0.347	0.064	-0.037	1.325
Farmsize	0.000	0.001	0.373	-0.001	0.002
Mark	0.088	0.076	0.245	-0.061	0.237
Jessore	-0.928***	0.260	0.000	-1.437	-0.419
Comilla	0.268	0.782	0.732	-1.266	1.801
Nilphamari	-0.221	0.643	0.731	-1.482	1.039
Thakurgion	-0.845**	0.379	0.026	-1.587	-0.103
_cut1	-0.262	1.465		(Ancillary	Parameters)
_cut2	0.377	1.465			
_cut3	2.003	1.466			

Single, double, and triple asterisk indicate corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

Appendix D: Appropriate Use Model

Rice Leaf Clipping

Table D.1
Adoption Probit Model for Rice Leaf Clipping

probit clippinguses mmedia fday visit ffs age agesq fam male prim hssc deg org size mark jessore comilla northern

Probit estimates			Number of obs	=	350
			LR chi2(17)	=	68.61
			Prob > chi2	=	0.0000
Log likelihood = -207.47224			Pseudo R2	=	0.1419

CLIPPINGUSES	Coef.	Std. Err.	P>z	[95% Conf.	Interval]
MMEDIA	0.240	0.524	0.647	-0.788	1.268
FDAY	0.223	0.243	0.360	-0.254	0.700
VISIT	0.105	0.162	0.518	-0.213	0.423
FFS	0.636	0.162	0.000	0.318	0.953
AGE	-0.010	0.031	0.746	-0.071	0.051
AGESQ	0.000	0.000	0.385	0.000	0.001
FAM	0.001	0.031	0.985	-0.060	0.061
MALE	0.682	0.316	0.031	0.063	1.301
PRIM	0.056	0.190	0.770	-0.316	0.427
HSSC	0.116	0.131	0.376	-0.140	0.371
DEG	0.455	0.219	0.038	0.026	0.885
ORG	0.416	0.157	0.008	0.108	0.724
FARMSIZE	0.000	0.000	0.826	-0.001	0.000
MARK	0.038	0.061	0.535	-0.082	0.159
JESSORE	-0.790	0.196	0.000	-1.175	-0.406
COMILLA	-0.844	0.224	0.000	-1.283	-0.406
NORTHERN	-0.962	0.243	0.000	-1.438	-0.485
_CONS	-1.126	0.715	0.115	-2.528	0.275

Table D.1.1
Marginal Effects after Adoption Probit

Marginal effects after probit
y = Pr(clippinguses) (predict)
= .45676488

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.096	0.208	0.645	-0.311	0.502	0.023
FDAY*	0.089	0.097	0.359	-0.101	0.278	0.109
VISIT*	0.041	0.064	0.517	-0.084	0.167	0.691
FFS*	0.248	0.061	0.000	0.128	0.367	0.509
AGE	-0.004	0.012	0.746	-0.028	0.020	37.463
AGESQ	0.000	0.000	0.385	0.000	0.000	1563.060
FAM	0.000	0.012	0.985	-0.024	0.024	6.282
MALE*	0.247	0.098	0.012	0.055	0.438	0.931
PRIM*	0.022	0.075	0.770	-0.126	0.170	0.243
HSSC	0.046	0.052	0.376	-0.056	0.147	0.383
DEG*	0.180	0.085	0.034	0.014	0.346	0.149
ORG*	0.163	0.061	0.008	0.043	0.282	0.614
FARMSIZE	0.000	0.000	0.826	0.000	0.000	254.294
MARK	0.015	0.024	0.535	-0.033	0.063	1.602
JESSORE*	-0.297	0.068	0.000	-0.430	-0.165	0.306
COMILLA*	-0.311	0.073	0.000	-0.454	-0.168	0.240
NORTHERN*	-0.339	0.070	0.000	-0.475	-0.202	0.163

TABLE D.2
Appropriate Use Probit model for Rice Leaf Clipping

probit clipapprop mills mmedia fday visit ffs age agesq fam male prim hssc deg org threeormore jessore comilla northern

Probit estimates				Number of obs = 159	
				LR chi2(16) = 23.720	
				Prob > chi2 = 0.096	
Log likelihood = -65.144				Pseudo R2 = 0.154	
Clipapprop	COEF.	STD. ERR.	P>Z	[95%	CONF. INTERVAL]
Mills	-2.811	2.951	0.341	-8.595	2.974
Fday	-0.283	0.638	0.657	-1.534	0.967
Visit	-0.415	0.381	0.275	-1.162	0.331
Ffs	-1.214	1.223	0.321	-3.611	1.183
Age	-0.001	0.048	0.987	-0.095	0.093
Agesq	0.000	0.001	0.789	-0.002	0.001
Fam	0.007	0.050	0.891	-0.091	0.105
Male	-1.633	1.532	0.286	-4.636	1.369
Prim	-0.038	0.509	0.940	-1.035	0.959
Hssc	0.538	0.517	0.298	-0.474	1.551
Deg	-0.064	1.007	0.949	-2.037	1.910
Org	-1.045	0.840	0.213	-2.691	0.601
Threeormore	0.062	0.289	0.831	-0.505	0.629
Jessore	2.110	1.475	0.153	-0.782	5.001
Comilla	1.826	1.573	0.245	-1.256	4.909
Northern	2.875	1.768	0.104	-0.591	6.341
_cons	3.219	4.815	0.504	-6.218	12.656

Table D.2.1
Marginal Effects after Rice Leaf Clipping Appropriate Use Probit

Marginal	effects	after	probit
Y	=	Pr(clipapprop)	(predict)
	=	0.157	

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	CONF. INTERVAL]	X
MILLS	-0.674	0.704	0.338	-2.053	0.705	0.729
FDAY*	-0.060	0.119	0.611	-0.293	0.172	0.101
VISIT*	-0.109	0.108	0.312	-0.320	0.102	0.730
FFS*	-0.315	0.332	0.342	-0.966	0.335	0.579
AGE	0.000	0.012	0.987	-0.023	0.022	39.101
AGESQ	0.000	0.000	0.788	0.000	0.000	1704.420
FAM	0.002	0.012	0.891	-0.022	0.025	6.347
MALE*	-0.571	0.517	0.269	-1.585	0.442	0.962
PRIM*	-0.009	0.119	0.939	-0.243	0.225	0.233
HSSC	0.129	0.125	0.302	-0.116	0.374	0.434
DEG*	-0.015	0.232	0.948	-0.469	0.439	0.195
ORG*	-0.304	0.275	0.268	-0.842	0.234	0.730
THREEORMORE*	0.015	0.070	0.832	-0.122	0.152	0.465
JESSORE*	0.648	0.415	0.119	-0.166	1.462	0.264
COMILLA*	0.579	0.496	0.242	-0.392	1.551	0.226
NORTHERN*	0.846	0.209	0.000	0.437	1.256	0.107

Bait Trap in Sweet Gourd

TABLE D.3
Adoption Probit Model for Bait Traps

probit trapuse mmedia fday visit ffs age agesq fam male prim hssc deg org jessore comilla northern farmsize mark

Probit estimates   Number of obs = 350
LR chi2(17) = 45.49
Prob > chi2 = 0.0002
Log likelihood = -189.33599   Pseudo R2 = 0.1072

TRAPUSE	COEF.	STD. ERR.	Z	P>Z	[95% CONF.	INTERVAL]
MMEDIA	0.203	0.473	0.430	0.668	-0.724	1.130
FDAY	1.116	0.249	4.490	0.000	0.628	1.603
VISIT	0.174	0.169	1.030	0.303	-0.157	0.506
FFS	0.557	0.170	3.280	0.001	0.224	0.889
AGE	0.024	0.034	0.710	0.480	-0.043	0.092
AGESQ	0.000	0.000	-0.620	0.537	-0.001	0.001
FAM	0.054	0.033	1.650	0.099	-0.010	0.118
MALE	-0.186	0.308	-0.610	0.545	-0.790	0.417
PRIM	0.353	0.194	1.820	0.069	-0.028	0.734
HSSC	0.177	0.130	1.370	0.172	-0.077	0.432
DEG	-0.049	0.234	-0.210	0.834	-0.508	0.410
ORG	0.164	0.167	0.980	0.328	-0.164	0.491
JESSORE	-0.391	0.215	-1.820	0.068	-0.812	0.029
COMILLA	-0.129	0.233	-0.550	0.580	-0.585	0.327
NORTHERN	0.168	0.242	0.690	0.488	-0.306	0.641
FARMSIZE	0.000	0.000	-0.930	0.352	-0.001	0.000
MARK	-0.085	0.070	-1.230	0.220	-0.222	0.051
_CONS	-1.724	0.765	-2.250	0.024	-3.225	-0.224

TABLE D.3.1
Marginal Effects After Bait Trap Adoption Probit

Marginal effects after probit
y = Pr(trapuse) (predict)
= .27256167

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	0.071	0.173	0.682	-0.269	0.411	0.023
FDAY*	0.418	0.090	0.000	0.242	0.594	0.109
VISIT*	0.057	0.054	0.291	-0.049	0.162	0.691
FFS*	0.183	0.054	0.001	0.076	0.290	0.509
AGE	0.008	0.011	0.479	-0.014	0.031	37.463
AGESQ	0.000	0.000	0.536	0.000	0.000	1563.060
FAM	0.018	0.011	0.098	-0.003	0.039	6.282
MALE*	-0.065	0.111	0.560	-0.283	0.153	0.931
PRIM*	0.123	0.070	0.080	-0.015	0.260	0.243
HSSC	0.059	0.043	0.172	-0.026	0.143	0.383
DEG*	-0.016	0.076	0.832	-0.165	0.133	0.149
ORG*	0.054	0.054	0.322	-0.052	0.160	0.614
JESSORE*	-0.123	0.064	0.053	-0.248	0.001	0.306
COMILLA*	-0.042	0.074	0.571	-0.187	0.103	0.240
NORTHERN*	0.058	0.085	0.500	-0.110	0.225	0.163
FARMSIZE	0.000	0.000	0.352	0.000	0.000	254.294
MARK	-0.028	0.023	0.219	-0.074	0.017	1.602

TABLE D.4
Appropriate Use Probit Model for Bait Traps

probit trapapprop mills mmedia fday visit ffs age agesq fam male prim hssc deg org jessore comilla northern threeormore

Probit estimates — Number of obs = 103.000; LR chi2(17) = 32.190; Prob > chi2 = 0.014; Pseudo R2 = 0.2262

Log likelihood = -55.061

TRAPAPPROP	COEF.	STD. ERR.	P>Z	[95%	CONF. INTERVAL]
Mills	0.164	1.710	0.923	-3.186	3.515
Mmedia	-0.003	0.876	0.997	-1.720	1.714
Fday	-0.106	1.276	0.934	-2.607	2.396
Visit	0.130	0.431	0.763	-0.714	0.975
Ffs	-0.808	0.717	0.260	-2.214	0.598
Age	0.093	0.083	0.265	-0.070	0.256
Agesq	-0.001	0.001	0.194	-0.003	0.001
Fam	-0.002	0.080	0.975	-0.159	0.154
Male	-0.539	0.653	0.409	-1.820	0.742
Prim	-0.214	0.677	0.752	-1.540	1.112
Hssc	-1.012	0.601	0.092	-2.189	0.166
Deg	-1.070	0.696	0.124	-2.433	0.294
Org	0.640	0.435	0.141	-0.213	1.493
Jessore	-0.839	0.681	0.218	-2.174	0.496
Comilla	0.820	0.426	0.054	-0.015	1.656
Northern	-1.055	0.627	0.093	-2.285	0.175
Threeormore	-0.396	0.371	0.285	-1.122	0.330
_cons	-0.318	3.907	0.935	-7.976	7.341

Table D.4.1
Marginal Effects after Bait Trap Appropriate Use Probit

Marginal	effects	after	probit
Y	=	Pr(trapapprop)	(predict)
	=	0.431	

VARIABLE	DY/DX	STD. ERR.	P>Z	[95% C.I.	]	X
MILLS	0.065	0.672	0.923	-1.252	1.381	1.039
MMEDIA*	-0.001	0.344	0.997	-0.675	0.673	0.029
FDAY*	-0.041	0.494	0.934	-1.010	0.928	0.194
VISIT*	0.051	0.167	0.761	-0.277	0.378	0.718
FFS*	-0.313	0.275	0.254	-0.851	0.225	0.641
AGE	0.037	0.033	0.265	-0.028	0.101	37.000
AGESQ	-0.001	0.000	0.195	-0.001	0.000	1515.410
FAM	-0.001	0.031	0.975	-0.062	0.060	6.605
MALE*	-0.212	0.251	0.397	-0.704	0.279	0.913
PRIM*	-0.083	0.259	0.748	-0.591	0.425	0.291
HSSC	-0.397	0.233	0.089	-0.855	0.060	0.456
DEG*	-0.351	0.163	0.031	-0.670	-0.031	0.126
ORG*	0.241	0.153	0.115	-0.059	0.540	0.689
JESSORE*	-0.302	0.211	0.153	-0.716	0.113	0.233
COMILLA*	0.318	0.159	0.045	0.007	0.630	0.301
NORTHERN*	-0.359	0.164	0.029	-0.681	-0.038	0.194
THREEORMORE*	-0.150	0.134	0.263	-0.414	0.113	0.194

Appendix E: Marginal Effects after Adaptability Probit

TABLE E.1
Marginal Effects After Adaptability Probit

y = Pr(ownexper) (predict)
= .70000641

VARIABLE	DY/DX	STD. ERR.	P>Z	[95%	C.I.]	X
MMEDIA*	-0.246	0.194	0.204	-0.626	0.133	0.023
FDAY*	0.128	0.082	0.118	-0.033	0.289	0.109
VISIT*	0.199	0.064	0.002	0.074	0.324	0.691
FFS*	0.058	0.060	0.331	-0.059	0.176	0.509
AGE	0.022	0.010	0.038	0.001	0.042	37.463
AGESQ	0.000	0.000	0.119	0.000	0.000	1563.060
FAM	-0.008	0.011	0.476	-0.030	0.014	6.282
MALE*	0.104	0.120	0.385	-0.130	0.338	0.931
PRIM*	0.055	0.069	0.423	-0.080	0.190	0.243
HSSC	0.038	0.057	0.498	-0.073	0.149	0.383
DEG*	0.117	0.076	0.124	-0.032	0.265	0.149
ORG*	-0.049	0.059	0.408	-0.164	0.067	0.614
FARMSIZE	0.000	0.000	0.500	0.000	0.000	254.294
MARK	0.032	0.024	0.175	-0.014	0.079	1.602
JESSORE*	0.301	0.053	0.000	0.196	0.406	0.306
COMILLA*	0.427	0.042	0.000	0.344	0.509	0.240
NORTHERN*	0.270	0.049	0.000	0.173	0.366	0.163

Appendix F: Regression Results for Informal Diffusion of IPM

oprobit simpleknowscore trained exposed age agesq fam male prim hssc deg org size mark jessore comilla nilphamari thakurgion

Table F.1
Ordered Probit Regession Model For Farmers' Awareness of Simple IPM Practices

Ordered probit estimates				Number of obs =	350
				LR chi2(16) =	149.76
				Prob > chi2 =	0.0000
Log likelihood = -470.51246				Pseudo R2 =	0.1373
SIMPLEKNOWSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
TRAINED	1.257***	0.185	0.000	0.894	1.619
EXPOSED	0.517***	0.185	0.005	0.155	0.880
AGE	0.024	0.023	0.313	-0.022	0.069
AGESQ	0.000	0.000	0.211	-0.001	0.000
FAM	-0.002	0.024	0.941	-0.048	0.045
MALE	-0.286	0.247	0.246	-0.770	0.197
PRIM	-0.006	0.153	0.968	-0.305	0.293
HSSC	0.178	0.109	0.103	-0.036	0.391
DEG	-0.002	0.179	0.990	-0.352	0.348
ORG	0.419***	0.127	0.001	0.169	0.668
SIZE	0.000	0.000	0.837	0.000	0.000
MARK	0.004	0.051	0.936	-0.095	0.103
JESSORE	-0.205	0.152	0.177	-0.502	0.093
COMILLA	0.666***	0.176	0.000	0.321	1.010
NILPHAMARI	0.536	0.378	0.156	-0.205	1.277
THAKURGION	-0.088	0.203	0.664	-0.487	0.310
			(Ancillary	parameters)	
_cut1	-0.214	0.555			
_cut2	0.585	0.557			
_cut3	1.646	0.560			
_cut4	2.483	0.562			

Single, double, and triple asterisks indicate the corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

oprobit intermediateknowscore trained exposed age agesq fam male prim hssc deg org size mark jessore comilla nilphamari thakurgion

Table F.2
Ordered Probit Regession Model For Farmers' Awareness of Intermediate IPM Practices

Ordered probit estimates				Number of obs	= 350
				LR chi2(16)	= 108.19
				Prob > chi2	= 0.0000
Log likelihood = -628.17862				Pseudo R2	= 0.0793
INTERMEDIATEKNOWSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
TRAINED	0.705***	0.172	0.000	0.368	1.042
EXPOSED	-0.381**	0.174	0.029	-0.722	-0.039
AGE	-0.020	0.023	0.387	-0.064	0.025
AGESQ	0.000	0.000	0.335	0.000	0.001
FAM	0.014	0.023	0.541	-0.031	0.059
MALE	0.313	0.237	0.185	-0.151	0.778
PRIM	0.092	0.145	0.526	-0.192	0.375
HSSC	0.070	0.099	0.479	-0.125	0.265
DEG	0.181	0.169	0.285	-0.151	0.513
ORG	0.272**	0.122	0.025	0.034	0.510
SIZE	0.000	0.000	0.154	0.000	0.000
MARK	-0.116**	0.049	0.018	-0.211	-0.020
JESSORE	-0.320**	0.146	0.028	-0.606	-0.034
COMILLA	-0.261	0.166	0.117	-0.586	0.065
NILPHAMARI	1.003***	0.365	0.006	0.288	1.717
THAKURGION	0.290	0.197	0.140	-0.096	0.676
			(Ancillary	parameters)	
_cut1	-2.381	0.575			
_cut2	-1.616	0.545			
_cut3	-0.784	0.534			
_cut4	0.017	0.530			
_cut5	0.670	0.532			
_cut6	1.155	0.535			
_cut7	1.683	0.541			
_cut8	2.603	0.561			

Single, double, and triple asterisks indicate the corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

oprobit complexknowscore trained exposed age agesq fam male prim hssc deg org size mark jessore comilla nilphamari thakurgion

Table F.3
Ordered Probit Regession Model For Farmers' Awareness of Complex IPM Practices

Ordered probit estimates				Number of obs	= 350
				LR chi2(16)	= 108.53
				Prob > chi2	= 0.0000
Log likelihood = -371.94989				Pseudo R2	= 0.1273
COMPLEXKNOWSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
TRAINED	0.785***	0.186	0.000	0.421	1.149
EXPOSED	-0.216	0.188	0.249	-0.584	0.152
AGE	0.005	0.026	0.842	-0.046	0.056
AGESQ	0.000	0.000	0.608	-0.001	0.000
FAM	-0.010	0.025	0.705	-0.059	0.040
MALE	-0.330	0.267	0.217	-0.853	0.194
PRIM	-0.171	0.162	0.291	-0.488	0.147
HSSC	0.255**	0.123	0.039	0.013	0.496
DEG	-0.038	0.191	0.841	-0.412	0.336
ORG	0.041	0.133	0.760	-0.220	0.301
SIZE	0.000	0.000	0.131	0.000	0.000
MARK	-0.130**	0.053	0.015	-0.234	-0.025
JESSORE	-0.517***	0.159	0.001	-0.829	-0.205
COMILLA	-0.553***	0.185	0.003	-0.916	-0.191
NILPHAMARI	0.740*	0.426	0.083	-0.096	1.575
THAKURGION	-0.650***	0.220	0.003	-1.081	-0.220
			(Ancillary	parameters)	
_cut1	-1.701	0.604			
_cut2	-1.052	0.602			
_cut3	0.734	0.598			

Single, double, and triple asterisks indicate the corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

oprobit totalscore trained exposed age agesq fam male prim hssc deg org size mark jessore comilla nilphamari thakurgion

Table F.4
Ordered Probit Regession Model For Farmers' Awareness of All Types of IPM Practices

Ordered probit estimates				Number of obs	= 350
				LR chi2(16)	= 165.03
				Prob > chi2	= 0.0000
Log likelihood = -797.21278				Pseudo R2	= 0.0938

TOTALKNOWSCORE	COEF.	STD. ERR.	P>Z	[95% CONF.	INTERVAL]
TRAINED	1.191***	0.175	0.000	0.848	1.533
EXPOSED	-0.055	0.172	0.748	-0.392	0.282
AGE	0.001	0.022	0.959	-0.042	0.045
AGESQ	0.000	0.000	0.827	-0.001	0.000
FAM	0.009	0.023	0.701	-0.036	0.053
MALE	-0.038	0.234	0.872	-0.496	0.421
PRIM	-0.020	0.142	0.887	-0.299	0.259
HSSC	0.166*	0.098	0.089	-0.025	0.358
DEG	0.086	0.167	0.605	-0.241	0.414
ORG	0.348***	0.120	0.004	0.112	0.584
SIZE	0.000	0.000	0.201	0.000	0.000
MARK	-0.101**	0.048	0.034	-0.195	-0.008
JESSORE	-0.425***	0.145	0.003	-0.709	-0.141
COMILLA	-0.038	0.164	0.816	-0.359	0.283
NILPHAMARI	0.936***	0.357	0.009	0.236	1.636
THAKURGION	-0.059	0.194	0.761	-0.440	0.321
			(Ancillary	parameters)	
_cut1	-2.868	0.641			
_cut2	-2.604	0.595			
_cut3	-1.817	0.541			
_cut4	-1.195	0.530			
_cut5	-0.823	0.527			
_cut6	-0.270	0.525			
_cut7	0.079	0.526			
_cut8	0.525	0.527			
_cut9	0.876	0.526			
_cut10	1.233	0.527			
_cut11	1.535	0.529			
_cut12	2.034	0.533			
_cut13	2.429	0.538			
_cut14	2.739	0.544			
_cut15	3.255	0.565			

Single, double, and triple asterisks indicate the corresponding coefficients in the ordered probit model are significant at the 10%, 5% and 1% level respectively.

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