Factors Affecting Integrated Pest Management (IPM) Adoption and Pesticide Use in Kenyan Vegetable Farmers

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Thesis submitted to the faculty of Virginia Tech University in
partial fulfillment of the requirements for the degree of

Masters in Science
In
Agricultural and Applied Economics

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August 4, 2017
Blacksburg, Virginia

Keywords:
Integrated Pest Management, Kenya, Ordered probit,
Insect stress, Disease stress, Vegetables

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Abstract

This study identifies the factors influencing adoption of IPM practices and the number of pesticide applications in vegetable farmers in Kenya. Data used in this analysis were collected in a field survey in four counties of Kenya. Based on the number and type of IPM practices adopted, 263 vegetable farmers are categorized into low, medium or high IPM adopters. To analyze adoption, ordered probit and dichotomous probit models are used. The ordered probit model used to analyze adoption in the three vegetables as a group reveals that experience in vegetable cultivation and livestock owned have a positive impact on the probability of being a high adopter, while distance to the nearest town has a negative impact. The ordered probit models used for tomato and cabbage separately provide similar results. Experience in vegetable cultivation and distance to the nearest town have positive and negative impacts on adoption, respectively. The dichotomous probit models used to analyze adoption of pest resistant varieties and staking of tomatoes indicate that male farmers are more likely to adopt resistant varieties, but that the probability of adopting resistant varieties decline as the percentage of farmers in a ward receiving IPM training increases. The model also reveals that having off-farm income, distance from town and being credit constrained negatively affect adoption of staking. However, owning more livestock and being a member of a farm or community organization has positive impacts. For cabbage, both adoption of pest resistant varieties and nursery nets are negatively related to distance to town. Experience in vegetable cultivation has a positive impact while age has a negative impact on nursery net adoption. For all three vegetables, distance from town and lower insect and disease stress reduce pesticide application. For tomato farmers, having off-farm income, age, distance from town and lower disease stress all reduce pesticide application. For cabbage, pesticide use goes down with distance from town. Lower stress from insects reduces applications as well. These results indicate that being close to town is important for agricultural activities in general. Being farther away not only reduces the probability of IPM adoption but also reduces pesticide application.

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General Audience Abstract

This study identifies the factors influencing adoption of IPM practices and number of pesticide applications in vegetable farmers in Kenya. The sample size for this study includes 263 vegetable farmers. The survey was conducted in four counties of Kenya: Nyeri, Tharka Nithi, Nakuru and Bomet. The vegetables considered in this study are tomato, cabbage and French beans. Different econometric tools are used to analyze adoption of IPM practices and pesticide application for vegetables. It is found that experience in vegetable cultivation and number of livestock owned have a positive impact on the adoption of IPM practices. However, distance to the nearest town has a negative impact on adoption. Moreover, the number of times pesticides are applied to vegetables also declines as distance of the household from the nearest town increases. Farmers whose crops face less stress from insects and disease tend to apply pesticides fewer times as well. Results from this study indicate that being close to town is important for agricultural activities in general. Being farther away not only reduces the probability of IPM adoption but also reduces pesticide application.

Dedication

I dedicate this work to my mother and my late father.

Acknowledgements

I am very grateful to all the kind souls who have devoted their time and guided me with their wisdom over the last two years during my time at Virginia Tech (VT).

At first, I would like to thank Dr. George Norton, my advisor, for his tremendous support and guidance throughout the period. His door was always open for help regarding not only my research but any issue in general. It is needless to say that without his patience and advice I could not have come this far and it has been a great pleasure to work under his supervision.

I am also grateful to my other committee members for their valuable time and guidance. Especially during the latter part of my research, Dr. Catherine Larochelle has helped me tremendously. She has always been patient with my numerous questions. Her guidance with the research and tips for using STATA has made my life a lot easier. The detailed remarks of Dr. Dan Taylor has really helped me to produce an improved paper. I appreciate his guidance and support which has contributed to a great extent in my research.

My gratitude goes to the people of Kenya, the collaborators, supervisors, enumerators and the farmers of the villages who have helped me all the way in collecting the data for the research. Language would have been a great obstacle if not for the team, who have interpreted and conducted the interviews of the farmers and accumulated all the necessary information required in a short span of time. The name of Dr. Menale Kassie and Josphat Korir of ICIPE has to be mentioned here for their selfless support.

A very special thanks goes to all the wonderful people from my department at VT who have welcomed me with open hearts and have made my stay at Blacksburg a very smooth and blissful one. The friendship offered by my peers in the department and the support from the Bangladeshi community at VT never made me feel that I am away from home.

I would also like to express my appreciation towards my family members who were always by my side despite living miles apart; the love and prayers of my mother, my constant source of energy, have helped me come this far. My elder brother has always been the shade over my head in every aspect of life and my elder sister has always taken care of me like her own child. I am also glad that my wife could come here to stay with me during the last few months of the journey, when I needed her support the most.

I feel blessed to have had the opportunity to come to VT and stay in this beautiful town of Blacksburg. The two years I have spent here with all the wonderful people is definitely one of the best phases of my life.

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Chapter 1: Introduction

Almost 800 million people suffer from malnutrition in the world, most of whom are in Southern Asia and Sub Saharan Africa (SSA). The rapidly increasing demand for food makes the situation even more challenging, with the world population expected to exceed 9.5 billion by 2050. A 60 to 70 percent increase in food production will be required. Most of this increase must come from higher yields and reduced post-harvest losses, as the area under cultivation is not expected to expand. However, growth in crop yields have slowed in many areas due to reduced investments in agricultural research, increasing water scarcity, climate change, and biotic stresses. Globally, an average of 35 percent of crop production is lost to pre- and post-harvest pests (R. Muniappan and Elvis A. Heinrichs), underscoring the importance of improved pest management.

By 2060, the population of SSA alone could grow to 2.7 billion people from the present 1 billion (World Bank). In SSA, around 330 million young people are expected to join the labor market between 2010 and 2025, around 40 percent of them initially located in rural areas. Moreover, the pattern of food consumption is changing due to urbanization and a shift in dietary patterns towards increased fruit and vegetable consumption (FAO 2012). In most of SSA, producing vegetables for urban markets and for exporting is becoming more profitable for all producers, including many smallholder farmers, over time. Sithanantham contends that "production of vegetable crops by smallholder farmers in sub-Saharan Africa is fast changing from a subsistence activity to intensive cultivation, especially in areas with supplementary irrigation". These changes in agricultural markets create challenges and opportunities for farmers. But as indicated above, pests are a major impediment as well.

These patterns and challenges related to agricultural production in most of the developing world, including East Africa, can be observed in Kenya as well. Agriculture can be considered as the backbone of the Kenyan economy. This sector contributed directly and indirectly around 24 and 27 percent annually to the GDP in 2011, respectively (Research solutions Africa, 2015). Moreover, the agricultural sector is the means of livelihood for most of the rural population, making it even more important for food security and poverty reduction. Accordingly, the government identified agriculture as one of the key sectors to deliver the 10 percent annual economic growth rate envisaged under the economic pillar of its Vision 2030, a new long-term development blueprint for the country. The vision identifies that to achieve this kind of growth, “transforming smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector is critical” (Research solutions Africa, 2015).

1.1 Horticulture and Vegetables in Kenya

Horticulture is one of the leading contributors to the Agricultural GDP in Kenya and it continues to grow at between 15 and 20 percent per year (Research solutions Africa, 2015). Moreover, horticultural production has been the second most important foreign exchange earner in the agricultural sector over the past decade, with tea being the first (Ulrich 2014).

In the first decade after Kenyan independence in1964, horticultural exports grew 9 percent per year. Then from 1974-1983, the growth was 17 percent per year (Minot & Ngigi 2002). Growth slowed down in the 1980s and averaged about 4 percent per year around the 1990s. By the year 2000, horticulture exports amounted to US$ 270 million, which is 15 percent of Kenya’s total export economy. In 2011, it earned the country US$ 877.7 million in exports (Research solutions Africa, 2015). These exports have contributed to increased rural incomes and reduced rural poverty, through both direct production effects and linkage effects, as horticultural export earnings are re-spent in rural areas (Muendo & Tschirley, 2004).

However, in spite of all its promises, exports remain a small fraction of Kenya's horticultural sector. Over 90 percent of all fruit and vegetable production was consumed domestically (on-farm or domestic markets) in the 1990s (Muendo & Tschirley, 2004). The lion's portion of the absolute amount of growth has come from the domestic sector. In the 1990s, the domestic market accounted for 98 percent and 91 percent of the total growth in quantity of fruit and vegetable production, respectively. The local market is clearly dominant even after allowing for higher prices of export commodities (Muendo & Tschirley, 2004).

Unsurprisingly, while production of vegetables in Kenya is mainly carried out by small-scale farmers, only around 2 percent of the smallholders do so directly for export (Mithofer et al. 2008; HCDA 2010, Bawden et al, 2002). These farmers are estimated to account for 27 percent of exported vegetables (Jaffee 2003). Women generally focus on crops for household consumption, selling any excess, while men cultivate cash crops primarily for sale. This difference in focus leads to more of the agricultural income going to men than women (Research solutions Africa, 2015). Farmer's produce is generally marketed through the informal sector (open markets and kiosks) and only a small percentage (around 5 percent) is sold through supermarkets (Tschirley et al. 2004). However, supermarkets are popular among the high and middle income earners and is recognized as a growing channel (Research solutions Africa, 2015).

With rapid population growth, declining per capita production and self-sufficiency, changing eating habits, and urbanization going on around the world, demand for agricultural production has increased not only for the domestic but also foreign markets. Kenyan vegetables are exported mostly to the European Union (EU) and the Middle East (Harris et al. 2001). Other destinations include the United States, Japan, Russia, and South Africa. However, they face stiff competition in these markets due to the presence of many suppliers from Colombia, Ecuador, Ethiopia, Spain, Morocco, Israel, Egypt, India, and China (Muendo & Tschirley, 2004). This lucrative opportunity is also becoming more difficult to avail due to rising concerns in the destination countries over the quality of agricultural imports.

1.2 Problem Statement

Pests are a major impediment in crop production, including vegetable production in Kenya. The fact that insect pests and diseases generally limit production of vegetables has been substantiated in many surveys conducted in East Africa (Macharia, 2012). They reduce yields, hurt product quality, and keep farmers from raising their incomes. As a result, like many other farmers in the developing world, farmers in East Africa have resorted to the use of synthetic pesticides to manage pests. In fact, most smallholder vegetable farmers rely heavily on spraying a wide range of pesticides to reduce the damage caused by pests and diseases (Macharia, 2012).

The ideal situation for use of pesticides is that it will reach the target organism and decompose rapidly into harmless compounds, having achieved its intended effect. However, that does not always happen and pesticides are accompanied by different side effects, which include impairment of human and animal health, surface and ground water contamination, pest resistance and resurgences, reduction in natural enemy populations, damage to fisheries, fauna, and flora (Macharia, 2012).

The situation is aggravated by the fact that pesticides are often overused and misused by farmers, especially in the horticultural industry (Macharia et al., 2005, 2008; Asfaw et al., 2010). The improper handling was mainly through unsafe storage (23%), unsafe disposal of leftovers or rinsing empty pesticide containers (40%) or failure to wear the required minimum protective gear (68%). Over 81 percent of these farmers expressed the view that pesticides do have harmful effects on human health, livestock, beneficial arthropods, and on water (Macharia, 2012)[1]. Macharia notes that "it is remarkable that pesticide risk perceptions and previous experience/witness of a negative pesticide impact have no direct influence on farmer's pesticides handling practices. Hence, the learning effect of experience is very little." He goes on to argue that such a trend is alarming as the ill effects are not only limited to the health of farmers affected. Pesticide misuse throws the whole household and society at risk since water sources and the entire environment are affected (Macharia, 2012).

Overdose results in financial losses as pesticides, which can be expensive, are wasted and because it decreases yields due to phytotoxicity. Moreover, there is the increased likelihood of resistance development against pesticides. This can cause devastating large-scale effects on crop production leading to major financial setbacks (Meijden, 1998). Pesticide overuse also leads to destruction of natural control organisms, increasing the chances of pest resurgence (Meijden, 1998).

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[1] Similar findings on lack of association between handling practices and risk perceptions were reported other studies which showed that knowledge of the negative effects from pesticides was not directly reflected on the use of protective gears (Martinez et al. 2004) or farmer's crop production practices (Ecobichon 2001). Tucker and Napier (2001) also found similar results in Midwestern US farmers who heavily relied on chemical control even after being aware of potential negative effects of pesticides use.

In addition, pesticide misuse can be expensive in terms of indirect health costs. Macharia (2015) found that Kenyan farmers lose on average US$3.54/farmer/year on pesticide-related indirect health costs. This cost does not include the health costs of all individuals who can be exposed to pesticides (entire public, consumers, and hired workers). Neither does it include pesticide-induced chronic illnesses and deaths.

In addition to health and environmental hazards, the use and overuse/misuse of pesticides makes it difficult for farmers to export their products to countries with strict food safety regulations. This export constraint is especially an issue for exports of fresh vegetables to the European Union (including England) where consumers are increasingly concerned about food safety and the ethical and environmental conditions under which food is produced and distributed (Jaffee and Masakure, 2005). A focus on ensuring that Maximum Residue Levels (MRLs) of pesticides on fresh produce are not exceeded has led to an increasing emphasis on 'traceability'. This means that exporters want to be able to ensure quality and safety by tracing production back to the specific farm from where it came (Muendo & Tschirley, 2004). These regulations mean the few Kenyan smallholders who have succeeded in producing for the export market face daunting challenges if they are to maintain their participation.

1.3 Integrated Pest Management

Integrated Pest Management (IPM) has been suggested by researchers as a solution to these problems of pests and pesticide misuse. Integrated Pest Management is the process by which pests are managed by a combination of available tactics that minimize chemical use and their impacts on people and the environment. IPM tries to create an environment in which it is difficult for pests to appear or thrive, discouraging the use of pesticides. Pesticides are used as a last resort with IPM, and only in combination with other measures. The use of IPM can improve crop yields by reducing losses due to pests. If properly designed, IPM can reduce the harmful impacts of chemical use on health and the environment and improve farm incomes at the same time.

The USAID-funded Integrated Pest Management Innovation Lab or (IPM IL) in East Africa is attempting to do just that. The IPM IL, formerly known as Integrated Pest Management collaborative research support program (IPM CRSP), makes use of agricultural research expertise at American land grant universities to support developing country IPM researchers and research programs around the world. In East Africa, the IPM IL focuses its efforts on Kenya, Tanzania, and Uganda. It seeks to develop an ecologically-based IPM strategy shared by the countries to improve the productivity of high-value horticultural crops. Ecological IPM is used to provide farmers with an alternative, more environmentally-friendly path for improving agricultural productivity. This thesis will focus specifically on Kenya.

1.4 Objectives

The main objectives of this thesis are to assess the influencing factors of IPM adoption and pesticide use in specific vegetables in four counties of Kenya. The three specific vegetables considered are tomato, cabbages and French bean. The study will identify:

1. Who adopts IPM (more or less educated farmers, male or female).
2. Why farmers adopt IPM.
3. Why farmers reduce pesticide applications.

1.5 Hypotheses

In order to fulfill the objectives, the following hypotheses will be evaluated:

1. Farmers with secondary or more than secondary education are equally likely to adopt IPM practices compared to farmers with primary or no education.
2. Male farmers are equally likely to adopt IPM practices compared to female farmers.
3. Farmers who are members of a group/organization are no more likely to adopt IPM practices compared to farmers who are not.
4. Farmers who received IPM training are no more likely to reduce pesticide applications compared to farmers who did not.
5. Farmers facing lower insect or disease stress are equally likely to reduce pesticide applications compared to farmers who faced higher stress.

1.6 Methods

A field survey of 402 farmers conducted in four Kenyan counties is used in this analysis. The sample size, however, shrinks to 263 observations when only vegetable farmers are considered. The farmers were selected by stratified random sampling and the interviews were conducted during June and July, 2016. The process of data collection is discussed further in section 4.1. Ordered probit models are used in this study to estimate adoption of IPM practices in Kenya. The farmers are grouped into different categories based on the level of sophistication of the IPM practices adopted. The model includes various socio-economic characteristics of the respondents to assess their influence on adoption. An Ordinary Least Square analysis is used to analyze the number of pesticide application in vegetable production.

1.7 Organization of Thesis

The thesis is organized into five chapters. Chapter 2 provides a background for the study by discussing the economy, geography and demographics of Kenya. The four counties where the survey was conducted along with the three vegetables considered in this study are also discussed. Chapter 3 reviews literature on agricultural technology adoption and outlines the methodology used for this analysis. Chapter 4 presents the results while Chapter 5 concludes with summary, limitations, and policy implications.

Chapter 2: Background

2.1 Kenya

Kenya, located in Eastern Africa, borders the Indian Ocean, and lies between Somalia and Tanzania, as can be seen in Figure 2.1. It is a lower middle income country (since 2014) fighting with corruption and ethnic tensions to come out of poverty since its independence in 1963. Kenya has a medium Human Development Index (HDI)[2] of 0.555, giving it a rank of 146 among 188 countries.

Figure 2.1: Location of Kenya

[2] HDI measures overall well-being of a nation based on health, education and income. It ranges from 0 to 1 with a higher number indicating a better condition.

2.2 Geography

Kenya encompasses a land area of 580,367 square km and water of 11,227 square km. Its climate varies from tropical along the coast to arid in the interior. The west is a fertile plateau. Low plains rise to highlands in the central area bisected by the Great Rift Valley. 48.1 percent of the total land area of the country is used for agriculture, with the highlands being the most successful production region for agriculture. In fact, the Kenyan Highlands is the most successful agricultural production region in the whole of Africa (CIA). However, Kenyans do face challenges like deforestation, soil erosion, desertification and water pollution from industrial wastes, and increased use of pesticides.

2.3 Demographics

Kenya has witnessed a high population growth since the 1950s due to high birth rates and declining mortality rates. The current population is over 46 million with a density of 78/square KM and growth rate of 1.8 percent. Around 40 percent of Kenyans are under the age of 15 (with a median age of 19.5 years) resulting from high fertility, early marriage, and imperfections in family planning. This demographic structure gives rise to unemployment, lack of social services, and a strain on natural resources (CIA).

The country faced an HIV epidemic during the 1990s. The situation has improved since then, but the HIV prevalence rate is still 5.9 percent with 1.5 million people living with HIV/AIDS. The net migration out of the country is -0.2 migrants/1000 population because the country is the destination of many refugees from unstable neighboring countries who are fleeing political turmoil. The country has a life expectancy at birth of 64 years, infant mortality rate of 38.3/1000 live births, and hospital bed density of 1.4 beds/1000 population. The literacy rate, defined as “age 15 and over can read and write”, is 78 percent. (CIA)

Kenya is ethnically diverse with Kikuyu (22%) being the major ethnic group followed by Luhya (14%) and Luo (13%). This diversity has been the source of many ethnic clashes since independence. The major religion in Kenya is Christianism (83%) which is followed by Islam (11.2%). The most commonly spoken language is Kiswahili with English being widely spoken as well. Both are official languages of Kenya (CIA).

2.4 Economy

Kenya can be regarded as the economic and transport hub of East Africa. Its estimated GDP is US$ 69.17 billion (per capita of US$3,300) and it goes up to US$ 144.1 billion when adjusted for purchasing power parity (PPP). The growth rate of its real GDP is an impressive 6 percent and averaged over 5 percent for the last 7 years (CIA). The country also has a growing entrepreneurial middle class. However, Kenya has to struggle continuously with weak governance, corruption, unemployment/underemployment and lack of adequate infrastructure (CIA). In order to meaningfully address poverty and unemployment, it has to improve its growth rate even further; somewhere in the realm of 8-10 percent.

The industrial and services sector contributes around 18 percent and 49.3 percent to the GDP respectively. But, the agricultural sector is the most important, accounting for 32.7 percent of the GDP and employing around 75 percent of the labor force. While agricultural production in most of the developed countries is mechanized and capital intensive, over 75 percent of Kenyan agricultural output is from small-scale, rain-fed farming or livestock production.

Tourism is significant in Kenya's economy and is a good source of foreign currency. The sector contributes about 10 percent of the GDP and employs about 9 percent of the total wage workforce in the country (Ministry of Tourism). The country is host to Mount Kenya, Africa's second highest peak after Kilimanjaro, and several other world famous national parks. Kenya's varied and unique physiography supports abundant and varied wildlife of scientific and economic value.

Kenya exported goods and services worth around $6.363 billion in 2016. Major partners include Uganda (11.2%), USA (8.3%), Tanzania (8.1%), Netherlands (7.4%), UK (6%) and Pakistan (4.2%) (2015 figures). Major export commodities include tea, horticultural products, coffee, petroleum products, fish and cement. The country imported goods and services worth $16.34 billion in 2016. Major import partners are countries like China (30%), India (15.5%), UAE (5.7%), USA (4.8%) and Japan (4.7%) (2015 figures). Like other developing countries going through structural change, a lot of Kenya's import value is comprised of machinery and transportation equipment. It also imports petroleum products, motor vehicles, iron and steel, resins and plastics (CIA).

Kenya is one of the most unequal countries in the sub-region. Forty two percent of its population of 46 million, live below the poverty line.

2.5 Counties

In 2013, the government of Kenya was devolved into 47 counties. This devolvement was done in order to improve governance and management (World Bank).

The survey described in this paper was conducted in 4 counties of Kenya: Nyeri, Tharaka-Nithi, Nakuru and Bomet. Nyeri is located in the central region of Kenya while Tharaka-Nithi is located in the Eastern part. Nakuru and Bomet are located more towards the west in the Rift valley region.

A multistage sampling procedure was used to select counties, sub-counties, wards, villages and the farmers, respectively. The four counties were sampled purposively mainly considering the intensity of the relevant crop production. The resource constraints of the project were also kept in mind. The information provided below for the four counties was mostly sourced from their official websites.

2.5.1 Bomet County

Figure: Location of Bomet in Kenya

Bomet County is located in the former Rift Valley Province of Kenya. The area covered by this county is 1,997.9 km². It has an altitude of 1,962 meters and is green for most parts of the year with abundant rains for most of the months. January, however, is the driest month. It has a population of 730,129 (2009 census), 49 percent of whom were males while 51 percent were females. The county is one of the most densely populated counties in the region. Hence, there is a high labor force concentration, especially in its agricultural centers. With proper policies and assistance, this labor force can induce high agricultural production growth. Like most of Kenya, the county has a growing middle class.

Bomet has five sub-counties, which are the Sotik, Bomet Central, Bomet East, Chepalungu and Konoin. For the collection of our data, farmers were randomly sampled from the Bomet Central and Bomet East sub-counties.

Agriculture is the main strength of Bomet County with tea farming and dairy production leading in the sector. Coffee is also important in Bomet with production taking place in areas around the towns of Bomet, Tarakwa and Ndanai. In addition to cash crops, food crops are grown in the area, with maize being the area's staple food. Beans, Irish potatoes, millet, cabbages, onions, bananas and pineapples are grown both for consumption and sale. The produce is sold inside the county and to distant places like Nairobi and the former Nyanza Province. Commercial production of avocado, passion fruits, fish and poultry rearing are also picking up in the county. Trade is mostly conducted in the urban centers of the region. The presence of credit services, micro-finance initiatives and government loans for the youth and women facilitate trade.

2.5.2 Nyeri County

Figure: Location of Nyeri in Kenya

The county of Nyeri is located in central Kenya encompassing an area of about 3,337 square Km. The population of the county is 693,558 with a population density of 208 people per square Km. Nyeri is an emerging market with sound natural resources and infrastructure. This facilitates distribution of goods and services to the various urban centers in the Central region of Kenya.

The county has 758.5 square kilometers of arable land making agribusiness one of the main economic activities within the county. Coffee and dairy farming are the major income earners for a lot of the farmers in the county. Main economic activities involve tea, coffee, dairy farming, milk processing farms, maize, potatoes and cabbage. In Nyeri, agriculture currently employs 32.8 percent of the population.

There are 8 sub counties in Nyeri which are Mathira East, Mathira West, Kieni East, Kieni West, Nyeri Town, Mukurweini, Othaya and Tetu. For the purpose of this study, farmers were interviewed from the Mathira East, Mathira West and Kieni East sub counties.

2.5.3 Tharaka Nithi

Figure: Location of Tharaka Nithi in Kenya

Tharaka Nithi County is approximately 2,662 square kilometers in area. This includes the shared Mt Kenya forest, 360 square kilometers of which is estimated to be inside the county. This forest serves as a water catchment area for rivers, tourist attraction site, and source of fuel, fodder and honey. The highest altitude of the county is 5,200 m and the lowest is 600m above sea level. The rainfall varies a lot as well for this county. The high altitude areas experience reliable rainfall reaching as high as about 2,200mm. The middle areas of the county receive moderate rainfall. The lower regions receive low, unreliable and poorly distributed rainfall which can go as low as

500mm. The county also has bi-modal pattern of rainfall with long rains between the months of April and June and then short rains between the months October to December.

The county had a total population of 365,330 according to a 2009 census (population density of 140 per square Km). This is projected to be 478,570 (233,765 males and 244,805 females) by 2017. The county's annual population growth rate is 1.8 per cent. The primary economic activity in Tharaka-Nithi is agriculture. Planting of tea and coffee, subsistence dairy farming and rearing of other livestock are the major economic activities (Kenya Information Guide).

Tharaka-Nithi County has three sub-counties: Chuka / Igambangombe, Maara and Tharaka sub-county. The survey for this study was conducted at the Chuka and Maara sub-counties. As noted by the official website, the "topography of Chuka and Maara constituencies is greatly influenced by the Mt. Kenya volcanic activity leading to formation of 'V' shaped valleys within which the main tributaries of River Tana flows originating from Mt. Kenya forest. The region comprises of low, hilly, stony and sandy marginal lowlands with moderate forest cover."

2.5.4 Nakuru

Figure: Location of Nakuru in Kenya

Nakuru County is located in the former Rift Valley Province of Kenya, spanning an area of around 7496.5 square kilometers. The county is home to 1, 603, 325 people, with almost an equal ratio of male and female, according to the 2009 National Census. It is a cosmopolitan county, majority of its residents having migrated here for business and employment. All the major tribes of Kenya are represented well in its population.

The people of Nakuru are engaged in activities such as farming, livestock rearing and trade business. However, agriculture is the mainstay of Nakuru's economy. Nakuru is not only a picturesque county, but its weather is also conducive for large-scale farming, horticulture and dairy farming. Major food crops grown in Nakuru, consumed locally and also in neighboring towns and cities, include maize, wheat, beans, peas, cabbages, tomatoes, kales and carrots. The county has many large flower farms which employ a bulk of the local populace. Most of the flowers grown here are for export and are sent mainly to Holland, UK and Germany.

In addition to being an agriculturally-rich county, Nakuru is also blessed with some world renowned craters and lakes which are home to magnificent wildlife and birds. Hence, tourism is also a major economic activity in Nakuru. Moreover, there are many manufacturing industries in Nakuru, including wheat and maize flour processing plants. The government is the main employer in the county.

The county is made up of 11 sub-counties. Among them, surveys were conducted in Naivasha, Nakuru East and Bahati to collect data.

2.6 Vegetables considered in this study

The horticulture sector (including flowers, fresh fruits and fresh vegetables) contributes around 33 percent of agricultural GDP of Kenya. Moreover, the horticulture sector directly or indirectly employs over six million Kenyans. Although only 4 percent of the horticultural production is exported, it brings the country a large amount of foreign exchange earnings (National Horticultural Policy 2010). Exports of horticultural produce earned Kenya US$ 747.9 million in the year 2010. (USAID Kenya Horticultural Competitiveness Project)

This study examines three vegetables: tomato, cabbage and French bean. Although there are many vegetables, fruits, and flowers that contribute to agricultural production in Kenya, these three crops are important in terms of domestic consumption and export. In particular, this study identifies factors that influence farmer adoption of IPM technologies related to these three crops.

2.6.1 Tomato

Tomato is one of the most highly consumed vegetables in Kenya. It is grown for fresh market, processing, and export market. During 2014, the area under tomatoes was 24,074 hectares, production was 400,204 mt, and the value was US$ 113.5 million. The total production of tomatoes in the counties of Nakuru, Bomet, Tharaka Nithi and Nyeri was 17,510 tons, 10,750 tons, 3,230 tons, and 2,665 tons respectively (Economic Review of Agriculture).

2.6.2 Cabbage

Cabbage is one of the most highly consumed vegetables in Kenya and is grown in the wet areas of the country. In 2014, 442,569 mt of cabbage were produced in the country with a total value of US$ 47.1 million. Cabbage production was the greatest in Meru County, which accounted for 45 percent of total cabbage production in the country. The total production of cabbage in the counties of Bomet, Nakuru and Tharaka Nithi were 23,865 tons, 39,159 tons and 1,977 tons respectively (Economic Review of Agriculture).

2.6.3 French Beans

French beans have been a success story mainly in the horticultural export sector. They have higher financial gains per acre compared to traditional crops like maize. French beans have wide acceptability among producers as it has easy agronomic practices, a short growing period, and an established European market. Local consumption of French beans is small. Internationally, there has been considerable penetration of French bean exports from Kenya to the EU market. (EUROSTAT, 2009). The UK, for example, receives more than 60 percent of its total French bean imports from Kenya. Moreover, the export price per kilo of French beans increased from US$ 0.81 in 1990 to US$3.21 in 2007 (FAOSTAT, 2009).

Chapter 3: Literature Review and Methods

3.1 IPM Adoption

Adoption is a broad term even in the context of agricultural technologies. Hence, it is necessary to clarify what is meant by adoption in the context of this study. Bisanda et. al. (1998) defines three types of adoption: Incidence of adoption, Intensity of adoption and rate of adoption. The **incidence of adoption** can be defined as the ratio of the number of people who have adopted a technology to the sample size at a given point in time. The **intensity of adoption** can be defined as level of adoption of a given technology (for example, amount of fertilizer applied per hectare). Finally, the **rate of adoption** is defined as the ratio of the number of people who have adopted a technology over time to the sample size (Feder et. al., 1985).

In the context of this research, adoption basically means the incidence of adoption of different IPM practices at the time of data collection, i.e. in June and July 2016. In this case, however, it is inappropriate to measure adoption in the usual way because it is hard to define a cut-off point between adopters and non-adopters. Most farmers usually adopt some of the IPM practices in their farms and not others. Moreover, the complexities and sophistication of the different practices are also different. So, assigning equal weights to each practice and using them as a continuous variable can be unsuitable. This approach, however, is followed by D'Souza et al. (1993), Wollni et al. (2010) and Taklewood et al. (2012). But in this study, assigning equal weights to all practices has been avoided by categorizing adoption into low, medium and high categories. This approach also helps to avoid, to some extent, the arbitrary ranking of individual practices. The way that the dependent variable is constructed is discussed in sub-section 3.5.

3.2 Theories of Technology adoption

Over the years, authors have tried to explain the process of adoption using different theories. A few are discussed here briefly before delineating the one used for this paper.

The **diffusion of innovation theory** tries to explain the process of adoption in terms of different sequential stages. The first stage is the knowledge stage where an individual is introduced to a technology but lacks specific knowledge about it. Then comes the persuasion stage where that individual becomes interested in that technology and peruses to gain more information. Next is the decision stage in which the individual decides whether to accept or reject the technology, comparing the advantages to the disadvantages. The next stage, implementation stage, comes about only if the decision is to adopt the new technology. In this stage, the individual may use the technology in varying degrees and seek further information about it. Finally comes the confirmation stage where the individual decides to carry on with the technology to the fullest extent (Rogers, 1995). Clearly, there are shortcomings of this theory. For example, this theory does not talk about the rate of technology adoption. (Rogers, 1995; Liao, 2005).

The **theory of perceived benefits** (also known as the absorption theory or the theory of consumer attitude) discusses the reasons a technology is adopted. It states that a farmer will adopt a new technology if the anticipated benefits from it are greater than the benefits from the former technology. The weakness of this theory is that it does not explain the speed at which a technology is adopted (Kanter, 1983; Cohe, 1990; Liao, 2005; Pual and Motiwalla, 2007).

The **theory of rate of adoption** explains the speed at which a new technology is adopted. Rate of adoption is generally measured as the time needed for a certain percentage of farmers to adopt a new technology (Yates, 2011). This theory says that adoption starts off slowly and gradually. Then it will have a period of rapid growth that will taper off and become stable. Finally, the declining stage will set in (Rogers, 1995). The farmer's adopter category such as innovators, early adopters, late majority and laggards, has a role to play in the speed of adoption.

The theoretical framework of most modern adoption studies follows the theory of perceived benefits making the assumption that farmers will adopt an innovation if the expected net benefit of that innovation is greater than the net benefit of the current practice (Ricker-Gilbert et al., 2005). Other major underlying assumptions of most farm household technology adoption models are that of perfect competition and separability, meaning that production and consumption decisions are made separately by a farmer. However, rural households in developing countries are often characterized by imperfect competition, resulting in nonseparability. Nonseparability can also occur when there is imperfect substitutability of family and hired labor, difference in purchase and sales prices of inputs and outputs, and in the presence of interlinked transactions (Feder, 1993).

3.3 Methods for estimating adoption of Technologies

From the inception of agricultural technology adoption studies, there have been several methods used to measure adoption. Before going into the specific method that will be used for the current study, a brief exposition of some of the relevant methods/models are presented.

In order to empirically test for the determinants of the intensity of an innovation, older studies typically use some form of the linear, log-linear, or semilogarithmic regression equation. The parameters are then estimated using ordinary least squares (OLS) (Feder, 1993). Moreover, non-adopters are often completely excluded from the sample. Even when non-adopters are included, it creates clustering of observations, violating the OLS assumption of a continuous variable. All these inconsistencies mean that the parameter estimates are often biased and inconsistent. Also, there is a high probability that the predicted value of the dependent variable is negative, which is nonsensical. OLS estimation of equations with a dichotomous or limited dependent variable solves the problem of biasedness but the estimates are still inefficient because the error structure is heteroscedastic. Moreover, the error terms for a limited dependent variable is not normally distributed meaning that the classical hypothesis tests are not meaningful (Feder, 1993). Furthermore, the linear probability model assumes that the dependent variable is linearly related to the independent variables for their entire range of values. Hence, it does not take into account the diminishing marginal effects as the independent variables increase (Maddala, 1983).

To overcome these problems, the logit or probit models have been used for dichotomous adoption decisions (farmer either decides to adopt or not to adopt). The probit model is appropriate when the error terms are assumed to follow a normal distribution. Similarly, a logit model is appropriate when the error terms are assumed to follow a logistic cumulative distribution. The problem of heteroskedasticity is accounted for in these cases because a maximum likelihood estimator (MLE) is used to estimate the value of y given x (Woodridge, 2003).

There are numerous studies that have used the logit and probit models to measure adoption of agricultural technologies and practices. Kabir (2014) made use of the binary logistic regression model to see how each independent variable affect the probability of IPM adoption. Similarly, Harper et al (1990) used a logit model to identify significant characteristics associated with adopters and non-adopters. Isham (2002) used a probit model for analyzing the effects of social capital on fertilizer adoption in Tanzania. Halloway et al. (2002) used a Bayesian spatial probit model to analyze adoption of high yielding varieties of rice among Bangladesh farmers. Mbata (2001) used a multivariate probit model to estimate the determinants of animal traction adoption in Lesotho. Marenya & Barrett (2006) also uses a multivariate probit estimator using the MLE approach when they try to identify household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya.

A similar model, the tobit model (or the censored normal regression model), is also used in some studies (Bisanda et. al., 1998, for example). It is more appropriate when adoption involves the simultaneous decision regarding the intensity of utilization if adoption occurs. This model assumes that a large number of respondents do not adopt. For the rest of the respondents, the variables take on a wide range of values. Hence, the explanatory variables will influence both the probability of adoption and the intensity of adoption. Upadhyaya et al. (1990) and Otsuka and Gascon (1990) used this approach for the analysis of adoption of MV rice in Nepal and the Philippines.

3.4 Methods used in this study

In this study, the dependent variable, adoption, is discrete and takes on three different values (see section 3.5 for its construction). Hence, it should not be treated as a continuous variable. This discreteness of the dependent variable means that using a linear probability model, an application of the multiple regression model, has some drawbacks. As a result, using a probit model, which overcomes these drawbacks, is more appropriate. (Wooldridge, 2013). If the error is assumed to be a random variable with a mean of 0 and variance of 1, then we can use the probit model and estimate it by maximum likelihood (MLE) (Strauss et al., 1990). A probit model, with values between zero and one, is not ideal when the dependent variable has three discrete values. IPM in this case is not a single technology where the farmer just decides whether to adopt or not to adopt. Rather, IPM here is a package of different technologies. Hence, farmers have the option to choose from a wide variety of IPM practices. Therefore, it is not appropriate to label two farmers just as adopters when they might be very different in terms of the intensity of adoption. For example, while one farmer might have only adopted the practice of staking, another farmer might have adopted the practice of using bio-pesticide in her farm. Clearly, the second farmer has a higher intensity of IPM adoption compared to the first in regards to the sophistication of the methods used. So, it will be inaccurate to categorize both farmers as just IPM adopters.

For this study, a modified type of the probit model known as the **ordered probit** is more appropriate to look at adoption. The ordered probit model overcomes the disadvantage of the dichotomous probit model by allowing the dependent variable to take on values other than 0 and 1. Here, the dependent variable represents ordered responses depending on the complexity of the practice(s) a farmer has adopted. The sign of the parameter estimates readily tells us whether an independent variable has a positive or a negative effect on the probability of adoption. However, the marginal effect of a one unit change in the independent variable on the probability of adoption has to be calculated (Tjornhom, 1995).

Several agricultural adoption studies use the ordered probit model. Teklewold et al (2012) uses an ordered probit model in their study of adoption of multiple sustainable agricultural practices in Rural Ethiopia. They find that the probability and the extent of adoption are influenced by many factors including credit constraints, spouse education, rainfall and plot-level disturbances, household wealth, social capital and networks, labour availability, etc. Baidu-Forson et al. (1997) use an ordered probit model to estimate farmers' utility from adopting plants with different traits. They ranked eight different plant traits such as yield, perceptions and threshing to come up with this model. Negatu and Parikh (1999) combine a probit and an ordered probit model in their study conducted in Ethiopia to find out the relationship between farmers' perception of a technology and the probability of its adoption. They find that perception about a modern variety has a highly significant effect on adoption. Farm size, farm income and soil type also play a key role in adoption.

The ordered probit model used in this study can be expressed as follows:

$$Y_{ADPi} = \sigma_{ADP} + \alpha_{ADPi}Dem_i + \beta_{ADPi}Wel_i + \gamma_{ADPi}Net_i + \delta_{ADPi}Sor_i + \theta_{ADPi}Gen_i + \pi_{ADPi}IPM_i + \tau_{ADPi}County_i + \varepsilon_{ADPi} - - - - - (1)$$

Where Y_{ADPi} represents the category that the ith farmer is placed in based on her IPM adoption. Dem_i is a vector of observable demographic characteristics (e.g. education, experience, etc.). Wel_i denotes a vector of variables indicating the wealth of the ith household. Net_i and Sor_i are two dummy variables indicating whether the ith farmer is part of any network and whether she came in contact with an agricultural extension agent, respectively. Gen_i, a dummy variable, indicates the gender of the respondent while IPM_i represents IPM training received from different sources. The dummy variable $County_i$ indicates the county in which the household is located. Finally, ε_{ADPi} is the random error term representing the unexplained factors that affect the probability of adoption.

The OLS model used in this study can be expressed as follows:

$$Y_{APLi} = \sigma_{APL} + \alpha_{APLi}Dem_i + \beta_{APLi}Wel_i + \gamma_{APLi}Net_i + \delta_{APLi}Sor_i + \theta_{APLi}Gen_i + \pi_{APLi}IPM_i + \mu_i Stress_i + \tau_{APLi}County_i + \varepsilon_{APLi} - - - - - (2)$$

Where Y_{APLi} represents the average number of pesticides applications to the three vegetables in the last cropping season. Dem_i includes the same observable demographic characteristics as in equation 1. Similarly,Wel_i, Net_i, Sor_i, Gen_i, IPM_i and $County_i$ represent wealth, network, knowledge sources, gender, IPM training and county respectively, included in the equation exactly the same way as in equation 1. $Stress_i$ is a vector of two categorical variables indicating the severity of insects and diseases in the last vegetable season. Finally, ε_{APLi} is the random error term representing the unexplained factors that affect the application of pesticides. Each of these variables are discussed below in further details.

3.5 Dependent Variables

3.5.1 Ordered Probit

For the ordered probit model, farmers will be categorized into three discrete categories in regards to their level of adoption. The IPM practices considered in this study are listed in table 3.1, separated into simple practices and high complex practices. Based on the sophistication of practices adopted by the farmers, they are assigned into low, medium or high adoption categories. A farmer is assigned into the low category if she uses none or only one of the IPM practices, excepting the four practices considered as high complexity practices. A farmer is assigned into the medium category if she uses more than one IPM practice but none of the high complexity ones. Finally, someone is assigned to the high category if she uses any of the four high complexity practices, regardless of whether she is using other practices or not.

Table 3.1: IPM Technologies & Practices

General Practices
1. Using pest-resistant variety
2. Selecting healthy seeds/sanitizing seed treatment
3. Grow seedlings in trays with sterilized soil
4. Remove damaged plants
5. Hang pheromone trap
6. Hang yellow sticky trap
7. Staking of plants
High Complexity Practices
1. Using nursery nets
2. applying Trichoderma
3. applying microbial pesticide
4. bio-pesticide

In addition to the overall adoption model where all three vegetables are considered, ordered probit models will be used to analyze IPM adoption in tomato and cabbage production separately. The dependent variable measuring adoption is constructed in the same way.

Moreover, a dichotomous probit model is also used in this study. A separate analysis is done where adoption of a particular practice (for a particular vegetable) is taken as the dependent variable. In this case, the dependent variable is defined as a binary choice variable taking on the value of 1 when the farmer has adopted the practice and 0 otherwise. The MLE will be used for estimation in this case as well.

In the case of tomato, the practices of interest are staking of plants and use of pest-resistant varieties. Out of the 141 farmers who grew tomatoes, 52% and 35% say they use these two practices respectively. Although 72.3% say they removed damaged plants, the practice is not examined separately as it is a common practice among farmers even when they have not had exposure to IPM. It is considered in the overall adoption model, however.

In the case of cabbage (182 responses), 29 percent of farmers say they use a pest-resistant variety while 21 percent say they use nursery nets. Although 73 percent say they remove damaged plants, it is not considered for reasons explained earlier.

In the case of French Beans, there are 47 observations. While 38 percent of the respondents say they used a pest-resistant variety, 25 percent say they used healthy seeds and nursery nets. Almost 91 percent removed damaged plants. However, French Beans is not analyzed separately because of the small sample size.

3.5.2 OLS

For the purpose of examining pesticide application, the dependent variable is the average number of times pesticide is applied to the three vegetables in the last season. For example, if a farmer who grows tomato and cabbage only applied pesticides three times in the last season for each of the crop, then the value of the dependent variable in this case is 3. However, if someone who grows all three vegetables applied pesticide 3, 4 and 5 times to tomato, cabbage and French beans respectively, the value for the dependent variable is 4.

3.6 Independent Variables

The explanatory variables that are expected to influence the probability of adoption are listed below along with a brief explanation of why they are included and their expected signs.

1. Demographics

(a) Off farm income (Dummy variable)

A dummy variable 'Off-farm Income' has a value of 1 if the respondent say that he/she had any occupation other than agriculture (be it primary or secondary) and a value of 0 if agriculture is the only occupation. Smallholder farmers in Kenya might not be generating sufficient funds to invest in the farm. Hence, it is expected that a source of off-farm income might help provide the liquidity necessary for adoption of certain IPM practices.

(b) Age of the spouse with more information about crop production (years)

It is expected that an older age will negatively affect the probability of adoption. Decision makers are more likely to invest in the future productivity of their farms when they have a longer planning horizon. Younger farmers might also be able learn and adjust more easily. Moreover, some IPM practices may require physical labor which makes it easier for younger farmers to adopt (Marenya, 2007).

Marenya et al. (2007) find that the coefficient for age was negative for the four practices they considered. Similarly, Taklewold et al. (2012) also find that the number of practices adopted decreases with age. In both studies, the age of the household head was used. In the current study, a question was asked regarding who has the most information on crop production in the household. This allows us to consider the age of the spouse with more information on crop production. The implicit assumption is that the person who knows more about crop production has more influence in the decision making process regarding crops. For those instances where both spouses were equally knowledgeable about crops, the age of the respondent was considered.

(c)Education of spouse with more information about crop production (Years)

Formal schooling may enhance or at least signify the latent managerial ability and greater cognitive capacity among smallholder farmers (Marenya, 2007). Education can also be thought of as a proxy that measures the ability to decipher information (Feder, 1993). It has been common practice in adoption literature to include it as an explanatory variable. The exact way that it is included, however, differs from once case to another.

It is likely that the person who is most involved in farming decides about whether or not to adopt different IPM methods. It is not always necessary that the household head makes such decisions. Zepeda and Castillo (1997) and Teklewold et al (2012) make a similar argument in their papers. Therefore, when examining the role of human capital in IPM adoption, the education of the spouse with more information on crop production has been included in this study. In cases where the spouses are equally informed, the education level of the respondent is considered.

One approach to account for the impact of education on adoption is to construct a categorical variable for educational achievement, differentiating between primary and secondary education, and higher education (Marenya, 2007). In our case, we have constructed three levels of education: 0 to 8 years for none or primary, 9 to 12 years for secondary and 13 to 19 years for more than secondary. The first level, ‘no or primary’, is considered the base group. It is expected that households with secondary or more than secondary education would have a higher probability of adoption compared to the base group.

Strauss et al. (1990) find that farmer's education positively affects the adoption of new technology. Taklewold et al. (2012) find that the female spouse's education level has a positive impact on the adoption. They argue that "technology adoption decisions should not be viewed as an isolated decision, but as part of an overall household strategy, modelled as a joint household decision" (page 612). Harper et al. (1990) found in their study that education has a significant but negative effect on technology adoption, in contrast to most of the other studies. The education of farmers is important from a public policy point of view as well. The results from the literature implies that there should be significant investments in education in developing countries with a special focus on women.

(d)Family Labor (Number of persons)

Given that most of the labor for farm operations in subsistence households is provided by the family rather than hired, a lack of adequate family labor coupled with the potential inability to hire labor can seriously constrain adoption.

During the interview, the respondent was asked about how many of his/her family members live under the same roof. That question was then followed up with a question on how many of those family members work or are able to work. The number of family members who are able to work serves as a proxy for availability of family labor and is included in the explanatory variables. Marenya (2007) says that "Family labor assumes great importance given that low incomes constrain financial liquidity for hiring wage laborers, and given possible moral hazard problems associated with non-family labor calling for considerable supervision" (page 527). He goes on to argue that this makes the real cost of hiring labor even more than the observed cost.

In his research, Marenya finds that the number of adults per household was statistically significantly and positively associated with adoption as does Taklewold et al. (2012).

(e)Experience in vegetable cultivation (years)

Years of experience in vegetable cultivation is used as an explanatory variable to analyze adoption. Strauss et al. (1990) contends that experience should be positively related to the likelihood of adoption. With more experience, there is more crop related information available to the farmer. Experience may provide the farmer with general farming knowledge as well as specific farming knowledge about his or her own farm. Both age and years of experience are included as they have a relatively low correlation of 0.44.

(f)Distance to the nearest town and input dealer (Kilometers)

Distance, measured in KM, from the farm to the nearest town and agricultural input (seed, pesticides, etc.) dealer is included. The expected sign for both is negative meaning that the probability of IPM adoption should go down as the distance to these places goes up. The correlation between the two variables is around 0.35.

(g)Credit Constraint (Dummy Variable)

To construct a measure for the access to credit by the households, an approach suggested by Feder et al. (1990) is used. During the survey, the respondent was asked whether credit was needed and, if needed, whether he or she is successful in obtaining it. Households were then categorized as credit constrained (those who answered yes to the first and no to the second question) and credit unconstrained (those who answered yes to both questions or answered no to the first question) based on their answers. This approach is also used by Taklewold et al. (2012).

2. Wealth

In their paper, Taklewold et al. (2012) include total value of non-land assets, livestock ownership, and farm size as measures of wealth. A dummy variable was also included indicating whether the household received remittances and/or has access to off-farm work as an indicator of working capital. They found that "Wealth, as measured by the value of major household and farm equipment, positively influences the adoption of improved seed, inorganic fertilizer and conservation tillage, reflecting the capacity to purchase external inputs and to cope with greater risk" (page 615).

There might be a concern that some or all of the wealth variables are endogenous. This can happen if adoption of IPM practices results in improved profitability which in turn leads to increased ability to invest in livestock, land, or houses. Appropriate instrumental variables, if available, might be used to alleviate this problem. Otherwise, different robustness checks should be done before reaching a conclusion.

The following wealth indicators are included for this study:

(a)Primary material for the floor (Dummy)

The material of the floor is included in the model as a dummy variable. There are four responses associated with this question: Earth, cement, tile or wood. Earth is considered to be the base group and given a value of 0. Cement or tile are bundled as one meaning that the variable receives a value of 1 if the floor was made of either cement or tile. There are 0 responses for wood.

(b)Land Owned (Acres)

The literature suggests that land owned by farmers is a good indicator of wealth. Marenya (2007) finds that the probability of adopting certain practices is positively influenced by the total farm size operated by the household. However, land farmed is not included in the explanatory variables because it is highly correlated with land owned, which was already included.

(c)Livestock Owned (TLU)

The respondents were asked about how many cattle, plowing oxen, goats/sheep, donkey/mule and/or pigs the household owns. A standard practice in the literature is to convert the number of livestock into animal units. There are different weights for this conversion, which are mostly based on the location. The weights that seem appropriate for Kenya are based on Tropical Livestock Units (TLU). In this scheme, the following conversion factors are assigned: Cattle = 0.7, plowing oxen =0.7, sheep = 0.1, goats = 0.1, mule=0.7 and pigs = 0.2.

3. Social Network (Dummy Variable)

In most developing countries where information asymmetry is common, group membership or organizational membership plays an important role in technology adoption. In their paper, Taklewold et al. (2012) finds significant and positive effects of social capital and network on adoption. Similarly, Ricker-Gilbert et al. (2005) finds that farmers involved in the community have a higher probability of IPM adoption compared to farmers who were not. A dummy variable related to membership in any farm or community organization is included in this study and the value of 1 if the respondent or their spouse or both are members and 0, otherwise.

4. Agricultural knowledge source (Dummy Variable)

The farmers were asked how they receive advice or learn about agriculture. There are many responses for sources of information such as extension worker, neighbor or friend, and radio. However, only “coming in contact with an extension agent” (individual visit, field day, farmer field school) is included as a dummy variable because its impact on IPM adoption is expected to be important, especially when IPM is not already prevalent and the methods are fairly complex. Although the agents can only reach a limited number of farmers due to time and budget constraint, this dissemination tactic can help tailor an IPM package to each farmer’s specific needs (Harris et al., 2011). Ricker-Gilbert et al. (2005) also notes that extension agent visits can be a fast method for diffusing information. This dummy variable indicates whether or not a farmer has received advice from an agricultural extension worker in the past year. Its inclusion provides an indication of how effective agricultural extension is at promoting IPM adoption. It also may provide an indication of the farmer’s attitude towards innovation. The intuition is that farmers who seek out advices from extension workers are more likely to adopt new technologies. This means there is a possibility of an endogeneity problem with this variable.

5. Gender (Dummy Variable)

A dummy variable for the gender of the respondent or his/her spouse is included based on who has more information about crop production. The variable gender is equal to 1 if the person is ‘Male’ and zero if the person is ‘Female’. The expected sign of this variable is positive meaning it is expected that male respondents are more likely to adopt IPM practices than the female respondents. Quisumbing et al., (1995) notes that many African societies did not traditionally grant the females secure entitlement of land and property. Previous studies in Africa have also found that women often have lesser access to critical resources such as land, cash and labor which makes it more difficult for them to carry out expensive and labor intensive agricultural practices (De Groote and Coulibaly, 1998; Quisumbing et al., 1995).

6. Training related to IPM (Continuous variable)

A variable is included to determine whether IPM training leads to higher probability of adoption. This variable is not included as a dummy variable so that endogeneity can be avoided. The intuition is that when someone receives IPM training, others in the locality will learn from that individual over time (spillover effect). Hence, a continuous variable is constructed in a way that takes this effect into account. Everybody in a ward is assigned the same value depending on how many of its inhabitants have received IPM. That number is then divided by the total number of respondents from that ward so that the size of the ward is also accounted for. As an example, if there are 10 respondents from a ward and 2 of them received IPM, then a value of 0.2 is assigned to all 10 households in that ward. It is then multiplied by 100 to come up with this variable. Hence, it basically denotes the percentage of farmers in a ward who received IPM training. This variable is expected to have a positive effect on adoption.

7. County (Categorical variable)

A variable is constructed to account for the differences in the four counties that are considered in this study. 1, 2, 3 and 4 are assigned to Nyeri, Tharaka Nithi, Nakuru and Bomet. The county Bomet is considered as the base group.

8. Severity of insects and diseases (Categorical variable)

Two categorical variables indicating the severity of insects and diseases in the vegetables are included in the equation for pesticide application. During the interview, farmers were asked about the severity of insects and diseases that they faced in the previous year. There were four possible answers: none, low, medium or high. However, there were very few farmers who faced no stress related to insects or diseases. Hence, while constructing the categorical variables, none and low severity are bundled as one response named 'none or low'. Consequently, each of the variables have three stress categories: none or low, medium and high assigned the values of 1, 2 and 3 respectively. High stress (with value of 3) is considered as the base group. To illustrate with an example, if a respondent growing tomato and cabbage mention that the severity of insect pests was none or low (value of 1) for tomato and high for cabbage (value of 3), the average of the two is taken to construct the dummy variable for insect stress for vegetables. In this case the value is 2 and the associated severity is medium. A fractional value is rounded up to come up with the three insect stress categories for vegetables. The categorical variables for the disease stress is constructed in the same way. The expected signs for these variables are negative meaning that farmers are expected to reduce pesticide use if insect or disease severity are none or low or medium compared to high severity.

Chapter 4: Data and Results

4.1 Data Collection

The data for this study were collected in June and July, 2016. The questionnaire was prepared prior to the visit and was later modified in consultation with other stakeholders before being tested on farmers. The questionnaire, which had 12 sections, was used to collect information about demographics, pests and pesticide use. Four enumerators and a supervisor were trained for conducting the survey. Though the questionnaire was in English, the enumerators (who were fluent in both languages) were trained to ask the questions in the local kiswahili language understood by the farmers. After the enumerators practiced by interviewing each other, pre-testing was conducted where each enumerator interviewed 2 farmers. Local stakeholders helped in locating and contacting the farmers who consented to be part of the pre-testing process. Finally, minor modifications were made to the questionnaire based on the experience of the pre-test. The questionnaire was then coded into tablets which the enumerators used to conduct the face to face interviews of the 402 farmers. Within a selected household, farmers were interviewed only if they had adequate information on crop production.

The main survey was conducted in four Kenyan counties (Nyeri, Tharaka Nithi, Nakuru and Bomet) which were purposively selected based on the availability of the relevant crops (maize and vegetables) and budget constraints of the project. In Nyeri county, three sub-counties out of eight were purposively selected because they had irrigation projects which is essential for growing vegetables. A list of farmers was collected for each of the three sub-counties from the local authority and 96 farmers were selected via proportionate random sampling (based on number of farmers in each sub-county). Next, 100 farmers in Tharaka Nithi were interviewed. Two sub-counties out of three were purposively selected in Tharaka Nithi because of the importance of vegetable production in these areas. Farmers were then randomly selected from a list obtained from the local agricultural authority.

The next interviews were conducted in Nakuru county. In Nakuru, two sub-counties were randomly selected from eleven sub-counties. Proportional to the number of farmers living in each sub-county, 34 farmers were randomly selected from one sub-county and 65 farmers were randomly selected from the other sub-county. The rest of the farmers (107) were interviewed in the county of Bomet. Two sub-counties were randomly selected from the 5 sub-counties there. The farmers were then randomly selected from those sub-counties based on lists obtained from the local authority. The whole process of data collection was overseen by one of the authors.

4.2 Descriptive Statistics

The sample size shrinks to 263 observations when only the vegetable farmers are considered. The rest of the farmers cultivated maize but did not have any of the three vegetables considered in this study. Table 4.1 indicates the number of farmers in the sample and by county who cultivate tomato, cabbage and French beans. The table also shows that out of the 263 vegetable growers, 141 (53%) grow tomatoes, 182 (69%) grow cabbages and only 47 (18%) grow French Beans.

Table 4.1: Respondents in terms of crops cultivated

Crop	No. of Respondents	% of Respondents (out of 263)	Respondents by County
Tomato	141	54%	Nyeri=24 Tharaka=56 Nakuru=20 Bomet=41
Cabbage	182	69%	Nyeri=69 Tharaka=13 Nakuru=38 Bomet=62
French Beans	47	18%	Nyeri=36 Tharaka=10 Nakuru=1 Bomet=0

Source: Authors calculation based on survey data from Kenya.

Table 4.2: Summary statistics of Socio-economic Characteristics (263 observations)

Variable	Description	Avg.	Std. Dev.	Min	Max
dofffarm	1=has access to off farm income	0.45	0.50	0	1
ageinfo	Age of spouse with most information (years)	48.44	12.72	21	85
Education2	1=Primary or 0 2=Secondary 3=More than secondary	1.79	0.75	1	3
workable	Family members able to work	3.54	2.12	0	12
expveg	Experience in vegetable cultivation (years)	15.56	11.97	1	61
disttown	Distance to nearest town (KM)	15.98	13.70	1	90
distinput	Distance to nearest input dealer (KM)	5.32	7.74	0.1	71

dcredit	1=Credit Constraint	0.11	0.31	0	1
cementortile	1= floor made of cement or tile	0.55	0.50	0	1
acresowned	Land owned (acres)	3.29	3.75	0	30
livestock	In tropical livestock unit	2.78	2.43	0	24.5
dmember	1= member of farm or community org.	0.56	0.50	0	1
sorexten	1= came in contact with extension agents	0.69	0.46	0	1
dgender1	1=male	0.56	0.50	0	1
centipmveg	IPM training in the ward (continuous)	23.19	0.14	0	100
county	1=Nyeri 2=Tharaka 3=Nakuru 4=Bomet	2.44	1.20	1	4
applyveg_mean	Times pesticide applied	6.10	4.87	0	36

Source: Authors calculation based on survey data from Kenya.

Table 4.2 above presents the descriptive statistics of the sub-sample that is relevant for this study (farmers who grew the selected vegetables). The average respondent is 48.44 years old while the average experience in vegetable cultivation is 15.56 years. Distance from the nearest town and agricultural input dealer also varies greatly. While the average distance from the nearest town is around 16 KM, average distance from input dealers is only 5.32 KM. The table also shows that around 11% of the respondents say they are credit constrained. Moreover, 55% of the households have cement or tile as the primary floor material while the rest have floors made of earth, which is considered to be associated with lower economic status than cement or tile floor. In terms of other wealth indicators, the average household owns is 3.29 acres of land with a maximum of 30 acres and a minimum of 0 acres. In addition, 56% of households are members of a farm or community organization while 69% of the respondents say they came in contact with an extension agent in the last 12 months. Males and females are almost equally represented in this sample (not in terms of household heads but who has most information on crop production). The variable 'times pesticide applied' is the mean number of times pesticide was applied to each vegetable. On average pesticide was applied to tomato, cabbage or French beans for about six times during the last season.

Table 4.3: Level of education

Education of spouse with more info.	No. of respondents	Percent
Primary	106	40%
Secondary	105	40%
More than secondary	52	20%

Source: Authors calculation based on survey data from Kenya.

Table 4.3 illustrates the distribution of education levels among the respondents and their spouses. It shows that around 40% of the sample has no or primary education and the same percentage has secondary education while 20% of the sample had more than secondary education.

Table 4.4 shows the number of households from the four different counties. While almost equal number of households were randomly selected from each county, the representation changes when only vegetable producers are considered. As can be seen from the table 4.4, 31%, 29%, 24%, and 16% of the vegetable producers are in Nyeri, Bomet, Tharaka Nithi and Nakuru county respectively.

Table 4.4: Households from different counties

County	No. of respondents	Percent
Nyeri	80	31%
Tharaka Nithi	64	24%
Nakuru	42	16%
Bomet	77	29%

Source: Author's calculation based on survey data from Kenya.

Table 4.5 illustrates the percentage of adoption of the different IPM practices for the three vegetables. In this study, eleven IPM practices are considered. Seven of them are classified as simple practices while four of them are classified as complex practices (see table 4.5). Removal of damaged plants is the most adopted practice in all three vegetable cultivation. This is not surprising as this practice is almost general knowledge and does not really require training or even introduction. Other practices that are relatively highly used are staking of tomato plants and use of pest resistant variety for all three vegetables. Among the high complexity practices, the use of nursery nets is the most adopted practice with 23.4%, 21.43% and 25.53% of the farmers using it for tomato, cabbage and French beans respectively.

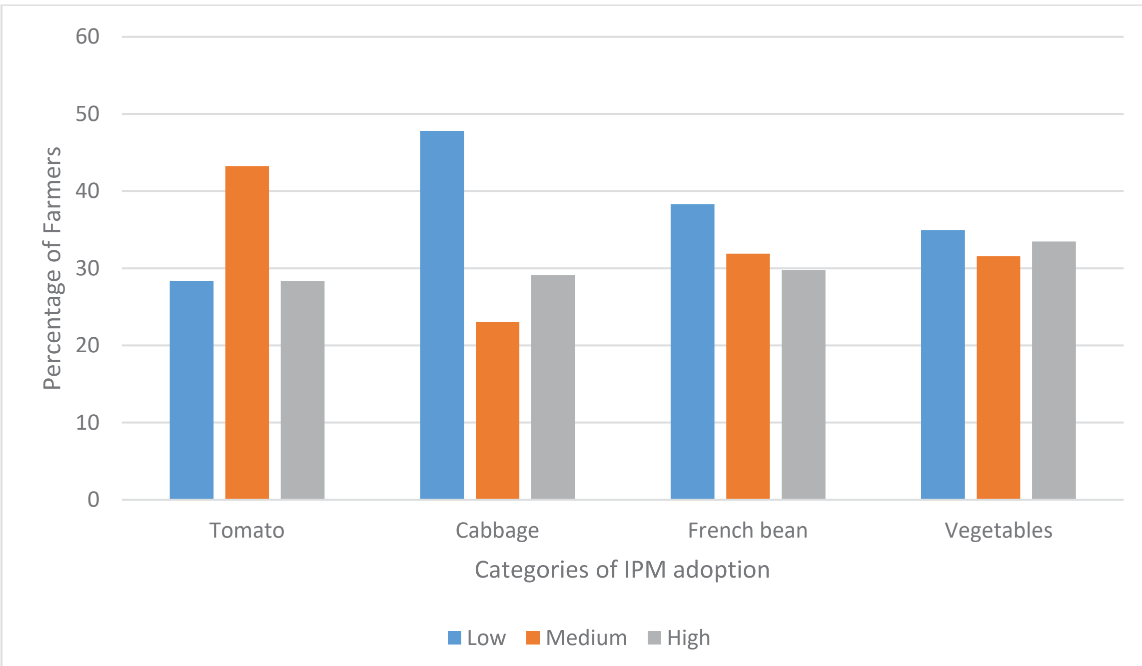
Table 4.5: Adoption of IPM practices for different crops

Simple Practices	**Tomatoes (141)**	**Cabbages (182)**	**French Beans (47)**
pest-resistant variety	34.75%	29.12%	38.30%
healthy seeds/sanitizing seed treatment	10.64%	13.74%	25.53%
seedlings in trays with sterilized soil	12.77%	7.14%	23.40%
Remove damaged plants	72.34%	73.08%	80.85%
pheromone trap	3.55%	3.30%	10.64%
yellow sticky trap	5.67%	3.85%	4.26%
Staking of plants	52.48%	NA	NA
Complex Practices			
Nursery nets	23.40 %	21.43%	25.53%
Trichoderma	1.42%	4.40%	6.38%
Microbial pesticide	2.13%	4.95%	6.38%
Bio-pesticide	5.67%	4.95%	2.13%

Source: Authors calculation based on survey data from Kenya.

French bean growers almost always use the highest percentage of the IPM practices compared to tomato and cabbage growers. This might be explained by the fact that French beans are mainly grown for exports and growers are cautious not to use a lot of chemicals due to stricter regulations in the export market.

Figure 4.1: Categories of adoption for each vegetable and overall



Source: Authors calculation based on survey data from Kenya.

To construct the dependent variable for the adoption model, farmers are categorized into three types: low adopter, medium adopter and high adopter. There is nearly an equal number of farmers who fall into each category when all three vegetables are considered (figure 4.1). Among vegetable growers, 35% farmers fall into the low category, 32 farmers fall into the medium category while 33 farmers fall into the high category. This result is a bit surprising considering that not much IPM intervention has occurred in the areas. However, the relatively high percentage of farmers in the high category of IPM adoption can be attributed to the fact that many of the farmers use Nursery

Nets (listed as a complex practice). Though there are many nursey net users, it should be noted that adoption of the other three complex practice is low.

The distribution of the three categories of adoption for each vegetables can also be seen from Figure 4.1. For tomato, most of the farmers fall into the medium adoption category. Approximately 28%, 44% and 28% of tomato farmers fall into the low, medium and high category respectively. Almost half of the cabbage farmers fall into the low IPM adoption category. Among cabbage farmers, 48%, 23% and 29% fall into the low, medium and high category respectively. Finally, around 38%, 32% and 30% of the French bean farmers fall into the low, medium and high adoption category respectively. It is unexpected that the percentage of high adopters is almost the same for the three vegetables. One would expect vegetables like French bean, which is grown mainly for export, to have a higher percentage of high IPM adopters.

Table 4.6: Severity of insects and diseases

Severity of Insect	**Tomato (141) %**	**Cabbage (182) %**	**French bean (47) %**	**Mean of 3 Vegetables (263) %**
None	1.42	6.04	4.26	4.18
Low	35.46	48.35	27.66	39.54
Medium	13.48	22.53	31.91	30.80
High	49.65	23.08	36.17	25.48
Severity of Disease				
None	0	5.49	6.38	3.42
Low	26.24	43.41	25.53	33.84
Medium	23.40	25.82	44.68	37.26
High	50.35	25.27	23.40	25.48

Source: Authors calculation based on survey data from Kenya.

Table 4.6 illustrates the severity of insects and diseases faced by the farmers in the last season by crop and for the sample. For tomatoes, almost half of the respondents mentioned that the severity of insect and disease related problems they faced was high. Fewer farmers say they faced high insects and diseases stress for cabbage. Around 48% of the cabbage farmers say they faced low severity of insect and around 43% say they faced low severity of disease. For French beans, a similar percentage of farmers reported facing low, medium and high insect stress (around 27%, 32% and 36% respectively). In the case of disease, most French bean farmers say they faced medium stress (45%) and around 25% and 23% say they faced low and high disease stress respectively. The last column of the table shows insect and disease severity for vegetables overall (its construction is described in the previous section). While only a few say that there was no insect or disease stress, the percentage of farmers reporting high stress overall is around 25% for both insect and disease.

4.3 Regression results: factors affecting IPM adoption

To identify the socio-economic characteristics that influence the adoption of IPM practices, Ordered Probit models are estimated. First, the model is estimated including all vegetable growers. Then, the same model is re-estimated for only tomato producers and only cabbage producers. Marginal effects, with standard errors clustered at the ward-level, indicating the probability of belonging to the low, medium, and high adoption category for all vegetable growers are reported in table 4.7. As expected, the results for the overall adoption model (all vegetables) reveal that experience in vegetable cultivation has a positive effect on adoption. Moreover, the distance of the farm to the nearest town has a negative effect on adoption. This is expected and reflects the difficulty of remote farms to access information and technologies. The only wealth indicator that has a significant and positive effect on adoption is livestock ownership indicating that wealthier farmers are in a better position to adopt. Though the other wealth indicators also have a positive sign, they are not statistically significant. Farmers in Nyeri, Tharaka Nithi and Nakuru counties are more likely to adopt the complex practices compared to farmers in Bomet. These results are expected as IPM outreach and extension for vegetables is less common in Bomet.

Though the signs of coefficients of the ordered probit model indicate whether a variable has positive or negative effect on the probability of adoption, the values are not readily interpretable. The marginal effects of changes in the regressors on the probabilities of adoption need to be computed in order to obtain interpretable results. The marginal effects are reported in Table 4.7.

Table 4.7: Comparison of Marginal Effects for different categories of adopters

VARIABLES	Low adoption dy/dx	Medium adoption dy/dx	High adoption dy/dx
Dofffarm	0.048	-0.000	-0.048
	(0.045)	(0.002)	(0.046)
Ageinfo	0.004	-0.000	-0.004
	(0.003)	(0.000)	(0.003)
2.education2	-0.063	-0.001	0.064
	(0.043)	(0.003)	(0.043)
3.education2	-0.000	0.000	0.000
	(0.065)	(0.004)	(0.062)
Workable	-0.013	0.000	0.013
	(0.013)	(0.001)	(0.013)
Expveg	-0.004**	0.000	0.004**
	(0.002)	(0.000)	(0.002)
Disttown	0.006***	-0.000	-0.006***
	(0.002)	(0.000)	(0.002)
Distinput	-0.000	0.000	0.000
	(0.003)	(0.000)	(0.003)
1.dcredit	-0.035	-0.001	0.036
	(0.083)	(0.006)	(0.088)
1.cementortile	-0.052	0.001	0.052
	(0.058)	(0.003)	(0.056)
Acresowned	-0.005	0.000	0.005
	(0.018)	(0.000)	(0.018)
Livestock	-0.028*	0.000	0.028*
	(0.017)	(0.001)	(0.016)
1.dmember	-0.053	0.001	0.052
	(0.044)	(0.002)	(0.044)
1.sorexten	-0.018	0.000	0.018
	(0.049)	(0.001)	(0.048)
1.dgender1	-0.022	0.000	0.022
	(0.035)	(0.001)	(0.034)
Centipmveg	0.002	-0.000	-0.002
	(0.002)	(0.000)	(0.002)
1.county	-0.311***	0.047***	0.264***
	(0.056)	(0.018)	(0.056)
2.county	-0.342***	0.039**	0.303***

	(0.048)	(0.020)	(0.049)
3.county	-0.272***	0.052***	0.220***
	(0.081)	(0.016)	(0.078)
Observations	263	263	263

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results indicate that farmers are more likely to be high IPM adopters as their experience in vegetable cultivation goes up. When the dependent variable is equal to 3, meaning that the respondent has adopted highly complex IPM practices, the *expveg* variable has a coefficient of 0.004. This means that an additional year of experience increases the probability of being a high adopter by 0.4% on average with everything else constant. This result is significant at the 5% level. One additional KM of distance from the nearest town decreases the probability of being high adopter by 0.6%, significant at the 1% level. Owning livestock has a slightly higher impact on adoption: an additional unit of livestock ownership increases the probability of adoption by 2.8%. This result is significant at the 10% level. Being in counties other than Bomet has a highly positive impact on the probability of being a high adopter. Being located in Nyeri, Nakuru and Tharaka Nithi increases the probability by 26.4%, 30.3% and 22% respectively compared to Bomet. All three results are significant at the 1% level.

Table 4.8 presents the marginal effects of changes in regressors on the probability of being in the three different categories of IPM adoption for tomato farmers. The results are mostly in tandem with the overall ordered probit model. Having off-farm income for tomato farmers decreases the probability of being a high IPM adopter by 11.1%, significant at the 10% level. Like the overall model, distance from town has a negative impact on the probability of being a high adopter. As distance goes up by a KM, the probability goes down by 0.4%. Having secondary education decreases the probability of being a high adopter compared to having no or primary education. Though this result is significant at the 5% level,

Table 4.8: Marginal Effects for different categories of IPM adopters for tomato

VARIABLES	(Low) dy/dx	(Medium) dy/dx	(High) dy/dx
dofffarm	0.109*	0.002	-0.111*
	(0.057)	(0.009)	(0.059)
ageinfo	0.004	0.000	-0.004
	(0.003)	(0.000)	(0.003)
2.education2	0.115**	0.001	-0.116*
	(0.056)	(0.014)	(0.061)
3.education2	0.023	0.004	-0.027
	(0.075)	(0.013)	(0.088)
workable	-0.003	-0.000	0.003
	(0.015)	(0.000)	(0.016)
expveg	-0.004**	-0.000	0.004**
	(0.002)	(0.000)	(0.002)
disttown	0.004**	0.000	-0.004**
	(0.002)	(0.000)	(0.002)
distinput	-0.003	-0.000	0.003
	(0.003)	(0.000)	(0.003)
1.dcredit	0.052	-0.002	-0.049
	(0.089)	(0.010)	(0.079)
1.cementortile	-0.041	0.000	0.041
	(0.082)	(0.005)	(0.079)
acresowned	-0.002	-0.000	0.002
	(0.023)	(0.001)	(0.022)
livestock	-0.019	-0.000	0.019
	(0.017)	(0.001)	(0.017)
1.dmember	-0.001	-0.000	0.001
	(0.047)	(0.001)	(0.047)
1.sorexten	0.027	0.001	-0.028
	(0.052)	(0.004)	(0.055)
1.dgender1	-0.063	-0.000	0.063
	(0.056)	(0.005)	(0.054)
centipmtom	0.002	0.000	-0.002
	(0.002)	(0.000)	(0.002)
1.county	-0.452***	0.101*	0.352***
	(0.102)	(0.060)	(0.118)
2.county	-0.445***	0.105**	0.340***
	(0.075)	(0.053)	(0.060)
3.county	-0.350***	0.137***	0.213**
	(0.129)	(0.047)	(0.108)
Observations	141	141	141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

it is unexpected and quite hard to explain. Finally, compared to Bomet, the counties of Nyeri, Tharaka-Nithi and Nakuru have positive impacts on the probability of being a high adopter.

Table 4.9: Marginal Effects for different categories of IPM adopters for cabbage

VARIABLES	(Low) dy/dx	(Medium) dy/dx	(High) dy/dx
Dofffarm	-0.054	0.007	0.047
	(0.049)	(0.007)	(0.042)
Ageinfo	0.006*	-0.001*	-0.005*
	(0.004)	(0.000)	(0.003)
2.education2	-0.115	0.015	0.099
	(0.070)	(0.011)	(0.061)
3.education2	-0.039	0.007	0.031
	(0.083)	(0.015)	(0.068)
Workable	-0.018	0.002	0.016
	(0.013)	(0.002)	(0.012)
expveg	-0.008***	0.001***	0.007***
	(0.002)	(0.000)	(0.002)
disttown	0.006**	-0.001*	-0.006*
	(0.003)	(0.000)	(0.003)
distinput	0.011**	-0.002**	-0.010**
	(0.005)	(0.001)	(0.004)
1.dcredit	-0.101	0.008*	0.093
	(0.120)	(0.004)	(0.119)
1.cementortile	-0.065	0.009	0.056
	(0.072)	(0.012)	(0.061)
acresowned	0.021	-0.003	-0.017
	(0.016)	(0.002)	(0.014)
livestock	-0.025	0.003	0.022
	(0.019)	(0.003)	(0.016)
1.dmember	-0.072	0.010	0.062
	(0.072)	(0.011)	(0.061)
1.sorexten	-0.030	0.004	0.025
	(0.068)	(0.011)	(0.058)
1.dgender1	-0.015	0.002	0.013
	(0.035)	(0.005)	(0.030)
centipmcab	0.004	-0.001*	-0.003
	(0.003)	(0.000)	(0.002)
1.county	-0.201**	0.035**	0.165*
	(0.101)	(0.016)	(0.087)
2.county	-0.198	0.035**	0.162
	(0.173)	(0.018)	(0.159)
3.county	-0.197***	0.035**	0.162***
	(0.064)	(0.014)	(0.057)
Observations	182	182	182

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The marginal effects of the ordered probit model on the probability of being in the low, medium and high IPM adoption category for cabbage farmers are presented in table 4.9. Experience in vegetable cultivation and distance from the nearest town have positive effects on the probability of being a high adopter. While a year of experience increases the probability of being a high adopter by 0.7% (1% level of significance), an additional KM reduces the probability by 0.6% (10% level of significance). Moreover, the results reveal that an additional KM from the nearest input dealer reduces the probability of being a high adopter by 1% (5% level of significance). Age of the farmer has a negative impact on adoption. As age goes up by one year, the probability of being high adopter goes down by 0.5%.

4.4 Regression Results: Factors affecting adoption of individual IPM practices

This subsection presents the results for how the different factors mentioned earlier affect the adoption of certain IPM practices for individual crops. In case of tomatoes, adoption of pest resistant varieties and staking are the two practices analyzed. As mentioned earlier, among farmers who grew tomatoes, 34.75% use resistant varieties, and 52.48% out of them practiced staking of plants. Adoption of nursery nets and pest resistant varieties are the two practices considered for cabbage production. Among farmers who grew Cabbages, 29.12% used pest resistant varieties while 21.43% used nursery nets to exclude insects. Both adoption of pest resistant varieties and staking are listed as simple practices while using nursery nets is considered a complex practice.

4.4.1 Individual practices for tomato

The marginal effects of the probit model on the probability of adopting pest resistant varieties for tomato farmers are presented in the first column of table 4.10. The marginal effect of *distinput* is 0.008 and significant at the 5% level meaning that with each additional KM increase in distance from the farm to the nearest agricultural input dealer, the probability of adopting pest resistant varieties of tomatoes goes up by 0.8%. The opposite would generally be expected as being located close to an agricultural dealer should make adoption of a pest resistant varieties more likely.

However, one explanation could be that farmers are more likely to rely on dealers who are from the nearest town instead of just the closest dealer. An indication to support this hypothesis is the negative sign on *disttown* which implies that a larger distance from the nearest town decreases the probability of adopting pest resistant tomato varieties. This result, however, is not significant. The other unexpected signs in this model are for *sorexten* and *centipmtom.* The negative value (-0.106) of the dummy variable *sorexten* means that if someone received advice from an agriculture extension worker in the last 12 months, then she is 10.6% less likely to adopt pest resistant varieties. Similarly, the value of -0.005 on *centipmtom* means that as the percentage of farmers receiving IPM training in a ward goes up by 1%, the probability of adopting pest resistant varieties goes down by 0.5%. One possible reason why extension advice and IPM training might decrease adoption is that extension workers and trainers sometimes provide advice on appropriate chemical use rather than the types of IPM practices included in this study. Finally, the marginal effect of the dummy variable *dgender1* is 0.09 meaning that the probability of adopting resistant varieties goes up 9% if the farmer is male compared to female farmers.

Table4.10: Results for adoption of pest resistant variety and staking for tomatoes

VARIABLES	(Resistant) dy/dx	(Staking) dy/dx
dofffarm	0.105	-0.157**
	(0.083)	(0.079)
ageinfo	0.001	0.002
	(0.003)	(0.004)
2.education2	-0.154	0.040
	(0.104)	(0.064)
3.education2	-0.041	-0.074
	(0.111)	(0.092)
workable	0.014	-0.031*
	(0.027)	(0.018)
expveg	0.002	0.000
	(0.003)	(0.004)
disttown	-0.005	-0.007**
	(0.004)	(0.003)
distinput	0.008**	0.007
	(0.004)	(0.006)
1.dcredit	-0.149	-0.260***
	(0.120)	(0.086)
1.cementortile	0.115	0.038
	(0.099)	(0.090)
acresowned	-0.014	-0.013
	(0.019)	(0.028)
livestock	-0.019	0.073***
	(0.023)	(0.015)
1.dmember	-0.004	0.156**
	(0.112)	(0.062)
1.sorexten	-0.106*	-0.113
	(0.064)	(0.081)
1.dgender1	0.091*	0.049
	(0.052)	(0.090)
centipmtom	-0.005**	0.001
	(0.002)	(0.003)
1.county	-0.093	0.108
	(0.115)	(0.095)
2.county	-0.052	0.392***
	(0.098)	(0.073)
3.county	-0.109	0.268**
	(0.125)	(0.106)
Observations	141	141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The second column of Table 4.10 presents the marginal effects of covariates on adoption of staking of tomatoes. The results show that having off-farm income and being further away from the nearest town by one KM decreases the probability of adoption by 15.7% and 0.7% respectively at 5%

level of significance. The former result can be explained by the fact that having access to off-farm income means that there is less time (labor is held constant) remaining for household members for labor intensive practices such as staking. Similarly, the negative impact of distance from the nearest town can be explained by the similar argument provided earlier: farmers are dependent on the nearest town for inputs and materials and further away they are, the higher the transaction costs are. The significant impacts (at the 1% level) of liquidity and wealth indicators on the probability of adoption of tomato staking should be noted from the table. It shows that being credit constrained decreases the probability of adoption by 26% while each additional livestock unit increases the probability of adoption by 7.3%. This result makes sense as staking can involve materials that are relatively expensive and so wealthier households are more likely to be able to afford staking. The table also shows the expected result that being a member of a farm or community organization increases adoption probability. However, the negative impact of having more family members (who are able to work) on adoption is unexpected because a labor intensive practice like staking should be made easier with availability of more family members.

4.4.2 Individual Practices for Cabbage

The marginal effects on the probability of adoption of pest resistant varieties are presented in the first column of table 4.11. As expected, *disttown* has a negative effect on adoption. With one KM increase in distance to town, the probability of adoption goes down by 0.8% and is significant at the 5% level. The results also show that being credit constrained has a negative impact on adoption.

Table 4.11: Adoption of pest resistant variety and nursery nets for cabbage

VARIABLES	(Resistant) dydx	(Nets) dydx
dofffarm	0.036	-0.006
	(0.079)	(0.068)
ageinfo	-0.002	-0.007***
	(0.004)	(0.002)
2.education2	-0.072	0.027
	(0.077)	(0.074)
3.education2	0.058	-0.089
	(0.086)	(0.102)
workable	0.017	0.008
	(0.019)	(0.013)
expveg	0.001	0.008***
	(0.003)	(0.002)
disttown	-0.008**	-0.005***
	(0.003)	(0.002)
distinput	-0.001	-0.004
	(0.004)	(0.005)
1.dcredit	-0.205*	0.087
	(0.105)	(0.118)
1.cementortile	-0.031	-0.043
	(0.064)	(0.081)
acresowned	-0.005	-0.023
	(0.020)	(0.016)
livestock	0.006	0.037*
	(0.014)	(0.021)
1.dmember	-0.051	0.029
	(0.071)	(0.062)
1.sorexten	0.048	0.058
	(0.091)	(0.061)
1.dgender1	0.102	-0.075
	(0.078)	(0.049)
centipmcab	0.000	0.005
	(0.003)	(0.003)
1.county	0.047	0.016
	(0.097)	(0.089)
2.county	-0.049	-0.037
	(0.167)	(0.085)
3.county	0.049	0.062
	(0.101)	(0.088)
Observations	182	182

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The second column of table 4.11 illustrates the results of the adoption of nursery nets, which is listed as a complex IPM practice. It provides similar results to the overall ordered probit adoption model where all three vegetables are considered, indicating that the findings of the overall model are robust. Age of the farmer (with more information) has a significant negative impact on adoption of nets. A one year increase in age reduces probability of adoption by 0.7% (1% level of significance). Experience in vegetable cultivation and distance from the nearest town also have the expected signs. A one unit increase in experience increases the probability of adoption by 0.7% while one unit increase in distance decreases the probability by 0.5%. Both are significant at the 1% level. Moreover, a one unit increase in livestock ownership increases adoption probability by 3.7% (significant at the 10% level). However, unlike the adoption model for all vegetables, none of the county variables are significant.

4.5 Regression results: Factors affecting pesticide application

This sub-section presents the results for the OLS model used to analyze the factors affecting pesticide application in the three vegetables (first column of table 4.12). Similar to the adoption model, distance to the nearest town has a significant (at the 1% level) and negative impact on pesticide application. Though the coefficient is small (-0.05), it leads to a similar conclusion to those from the adoption models: farmers are town dependent with regards to access to agricultural inputs, be it for IPM practices or pesticides. The unexpected positive sign (5% significance level) on distance from nearest input dealer gives a similar indication that farmers rely more on shops and dealers based in the town. The number of livestock owned also has a small but significant (10% level) positive impact on pesticide application. The coefficient shows that as livestock owned increases by one unit, pesticide application increases by only 0.24 times.

Table 4.12 OLS results for pesticide application

VARIABLES	(Vegetables) dy/dx	(Tomato) dy/dx	(Cabbage) dy/dx
dofffarm	-0.720	-3.232***	0.388
	(0.523)	(0.884)	(0.397)
ageinfo	-0.030	-0.097**	-0.012
	(0.030)	(0.047)	(0.027)
2.education2	0.193	0.505	0.735**
	(0.631)	(1.259)	(0.367)
3.education2	0.491	0.750	0.759
	(0.807)	(1.268)	(0.716)
workable	-0.051	-0.072	-0.054
	(0.149)	(0.220)	(0.089)
expveg	0.023	0.038	0.017
	(0.026)	(0.052)	(0.027)
disttown	-0.050***	-0.088**	-0.023
	(0.015)	(0.041)	(0.015)
distinput	0.086**	0.068	0.006
	(0.041)	(0.052)	(0.030)
1.dcredit	0.648	-0.054	0.297
	(0.752)	(1.497)	(0.650)
1.cementortile	-0.450	0.293	-0.080
	(0.569)	(1.293)	(0.584)
acresowned	-0.140	0.005	-0.061
	(0.156)	(0.193)	(0.123)
livestock	0.241*	0.180	0.186
	(0.128)	(0.166)	(0.127)
1.dmember	-0.361	-1.269	-0.290
	(0.578)	(1.064)	(0.464)
1.sorexten	-0.458	-1.776	-0.458
	(0.817)	(1.476)	(0.533)
1.dgender1	0.620	1.140	-0.220
	(0.551)	(1.028)	(0.463)
centipmveg	-0.013		
	(0.034)		
1.dveg_disstrs2	-0.715		
	(0.862)		
2.dveg_disstrs2	-1.545*		
	(0.862)		
1.dveg_insstrs2	-1.704**		
	(0.814)		
2.dveg_insstrs2	-2.041***		
	(0.576)		
1.county	1.512	-0.941	1.304*
	(0.947)	(1.627)	(0.719)
2.county	2.246***	0.927	-0.060
	(0.719)	(1.119)	(0.693)
3.county	-0.601	-0.629	-0.647
	(0.844)	(2.082)	(0.410)
centipmtom		-0.001	
		(0.035)	
1.tom_severedis2		-2.753*	
		(1.521)	
2.tom_severedis2		-2.530	
		(1.548)	

1.tom_severeins2		1.019	
		(1.033)	
2.tom_severeins2		-1.192	
		(0.879)	
centipmcab			-0.003
			(0.021)
1.cab_severedis2			0.884
			(0.618)
2.cab_severedis2			0.191
			(0.644)
1.cab_severeins2			-2.204***
			(0.798)
2.cab_severeins2			-1.487
			(0.953)
Observations	263	141	182

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The variable showing the percentage of farmers in a ward who received IPM training (*centipmveg*) does not have a significant impact on pesticide application. However, the dummy variables indicating the stress factor have the expected results. Farmers who said they faced no or low stress from diseases on average applied pesticides 0.7 times less than those who faced high stress (not significant), everything else equal. Similarly, farmers facing medium stress applied 1.5 times fewer pesticide controls (10% level) compared to farmers facing high disease stress. In the case of insect stress, the number of pesticide application was lower by 1.7 (5% level) and 2 (1% level) times respectively for none or low and medium stress compared to high stress. Finally, compared to Bomet, farmers in Tharaka-Nithi used 2.2 more pesticide applications on average (The ‘times’ here are the number of applications and does not mean multiplication).

The second column of table 4.12 presents the results for number of pesticide application among tomato farmers. Households with off farm income applied pesticides 3.2 times less on average (1 % level) compared to farmers without access to off farm income. Again, this might be because having off farm income means having less time for farm activities like pesticide application. Like adoption, age also has a negative impact on pesticide application in tomato cultivation. The number of pesticide application, being a physically intensive activity, goes down by 0.1 times as age goes up by one year (5% level). Distance from the nearest town has a negative impact on pesticide application. As expected, tomato farmers who faced lower disease stress used pesticides less frequently. Compared to those who faced high disease stress, the number of applications are 2.7 times (10% level) and 2.5 times (not significant) lower in those who faced low and medium stress respectively. However, the impact of insect stress on the number of pesticide application used in tomato cultivation is not at all significant.

The results for the pesticide application model among cabbage farmers are presented in the third column of table 4.12. This model has fewer significant variables than the previous two pesticide application models for all vegetables and tomato production. However, the impact of insect stress is highly significant. Compared to farmers who faced high insect stress, those facing none or low stress had 2.5 (1% level) fewer pesticide applications. These results might be indicative of the fact that tomato farmers are more concerned with disease stress while cabbage farmers are more concerned with insect stress.

Chapter 5: Summary and Conclusions

5.1 Summary

The objective of this thesis is to identify the factors influencing adoption of IPM practices and pesticide application among vegetable farmers in Kenya. The three vegetables considered are tomato, cabbage and French bean. Descriptive statistics and different regression methods are used for the analysis. An overall adoption model (using ordered probit) including all three types of vegetable growers is used to analyze adoption. In addition, ordered probit and dichotomous probit models are used to analyze adoption for individual vegetables and IPM practices. OLS regression is used to analyze the determinants of pesticide use. French bean is not analyzed separately due to inadequate sample size. However, French bean is included in the overall adoption model.

Five hypotheses, three for adoption and two for pesticide use, are tested in this paper. The first hypothesis is that farmers with secondary or more than secondary education are equally likely to adopt IPM practices compared to farmers with primary or no education. In case of the ordered probit model where all the practices and vegetables are considered, the results (table 4.7) show that farmers with secondary and more than secondary education are not significantly more likely to adopt complex IPM practices compared to farmers with primary or no education. The same is true for individual vegetables (tables 4.8 and 4.9). The probit models used for analyzing adoption of individual practices also provide a similar result (tables 4.10 and 4.11). It shows that there is no significant impact of being in the secondary education or more than secondary education category on the probability of adoption. These results suggest that the first hypothesis cannot be rejected.

The second hypothesis is that male farmers are equally likely to adopt IPM practices compared to female farmers. The ordered probit results (tables 4.7, 4.8 and 4.9) show that there is no significant difference between male and female vegetable farmers in terms of adoption. The same is true for the dichotomous probit models for adoption of staking in tomatoes, adoption of resistant varieties in cabbage and adoption of nursey nets for cabbage. However, male tomato farmers are significantly more likely to adopt pest resistant varieties compared to their female counterparts (table 4.10). Hence, this hypothesis cannot be rejected for the ordered probit models, neither can it be rejected for the models involving cabbage and staking of tomatoes. However, it can be rejected for adoption of pest resistant varieties for tomatoes.

The third hypothesis is that farmers who are members of a group/organization are no more likely to adopt IPM practices compared to farmers who are not. The ordered probit results do not show any significant difference in adoption between farmers who were members of a farm or community organization and those who were not. Even for the cases of individual practices, we get similar results except for adoption of staking for tomatoes. In this case, being a member significantly increases the probability of adoption of staking compared to non-members (table 4.10). So, while the third hypothesis cannot be rejected in most of the cases, it can be rejected for the case of staking in tomatoes.

The last two hypotheses are related to pesticide use. The fourth hypothesis is that farmers who received IPM training are no more likely to reduce pesticide applications compared to farmers who did not. The results in table 4.12 show no significant impact of IPM training on pesticide application. Hence, this hypothesis cannot be rejected as well.

The fifth and final hypothesis is that farmers who faced lower insect or disease stress are equally likely to reduce pesticide applications compared to farmers who faced higher stress. The OLS result shows that farmers who faced medium disease stress reduced the number of pesticide application by about 1.5 compared to those who faced high disease stress (table 4.12). In case of insect stress, pesticide applications go down for farmers with none or low or medium stress compared to farmers with high stress. Hence, the fifth hypothesis can be rejected.

5.2 Limitations and Extensions

An obvious limitation for the study is the small sample size. Though 402 farmers were interviewed for the survey, the sample size shrinks to 263 when only vegetable farmers are considered. Moreover, the sample size decreases even further when individual vegetables are considered. Ideally, crops should be analyzed individually with an adequate number of observations because of their unique characteristics. Though individual crop analysis is done in this study for tomato and cabbage, they had sample sizes of only 141 and 182 farmers respectively. Individual analysis for French bean, which has an even smaller sample size of 47, could not be done.

Another limitation for this study is that the analysis is based on a baseline survey. Two more surveys are planned for subsequent years after IPM testing and training is conducted in different areas of the country. As is generally the case with baseline surveys, the current adoption of complex IPM practices is low. Hence, it is difficult to identify which factors are really impacting adoption.

Another drawback with the survey is the technical glitches associated with the software used to conduct interviews. Though paperless interviews are convenient in many ways, there can be problems associated with them both during the interview and while transferring data after completion. Troubleshooting was difficult as the programmer was hard to reach from some of the remote areas where the interviews were conducted.

This study can be extended to gain more precise and meaningful information when the two subsequent phases are completed. Most of the households in this survey can be reached in the later phases (assuming low attrition) with the help of coordinates. That would allow for a panel data analysis to evaluate not only adoption (after the planned interventions) but retention over the years. In addition, research can be conducted to determine the impacts of different sources of information and training on adoption.

Few modifications could be incorporated in the questionnaire in order to facilitate and improve future analysis. The question about labor availability in the household could be made more precise. The current question asks how many of the family members living under the safe roof 'work or are able to work'. A separate question specifying how many of the family members actually work in the family farm can be more helpful. Moreover, questions regarding cost and prices of the different crops can be added to facilitate economic impact analysis of IPM adoption.

5.3 Conclusions and Policy Implications

The governments of various countries along with research and development organizations invest resources to encourage IPM adoption among farmers. The baseline situation in terms of adoption in each country needs to be determined in order to gauge the success of subsequent interventions. A baseline analysis also reveals the channels to tap into in order to achieve the desired objectives. It suggests whether the interventions need to be tailored to particular groups.

This study reveals that distance of a household from the nearest town has a significant negative relation with the probability of adopting relatively complex IPM practices. This relationship is also true for pesticide applications. This result indicates that farmers in general are town based with respect to agricultural products and sources of information. It implies that when planning interventions related to IPM, distance to town markets matters, perhaps due to marketing opportunities for vegetable products, ease of access to information, or some other reason. If widespread IPM adoption is desired, it may be necessary to address the distance constraint.

The results for individual practices and vegetables also provides important policy implications. It shows that for labor and material intensive practices like staking, availability of credit and liquidity are important. The significant positive impact of wealth indicators such as livestock owned re-enforces this conclusion. Policy makers should keep this in mind and make agricultural credit more readily available. If agricultural credit can be tied to adoption of IPM practices, it might help encourage IPM adoption and protect the environment, avoiding harmful health effects of pesticides.

This study reveals that the severity of insects and diseases has a high impact on the number of pesticide applications. Moreover, most of the farmers reported that they faced at least some stress from insects and diseases. Hence, in order to curb pesticide applications, attention should be given to reduce insect and disease related stress through interventions such as IPM.

As adoption of complex IPM practices is low, most of the models did not really pick up a positive association between receiving IPM training and adoption. Moreover, the instances farmers received IPM training are also low. However, with the successful implementation of the project, it both wmay increase in subsequent years.

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Appendix A: STATA Codes

Table 4.1

```
sum tom_yesno cab_yesno fb_yesno
tab tom_yesno codecot
tab cab_yesno codecot
tab fb_yesno codecot
```

Table 4.2

```
sum dofffarm ageinfo education4 workable expveg disttown distinput dcredit cementortile
acresowned livestock dmember sorexten dgender1 centipmveg county applyveg_mean if
no_veg>0
```

Table 4.3

```
tab education2 if no_veg>0
```

Table 4.4

```
tab codecot if no_veg>0
```

Table 4.5

```
tab1  tom_resistant cab_resistant fb_resistant tom_seeds cab_seeds fb_seeds tom_trays cab_trays
fb_trays tom_damage cab_damage fb_damage tom_phertrap cab_phertrap fb_phertrap
tom_sticky cab_sticky fb_sticky tom_staking tom_nets cab_nets fb_nets tom_tricho cab_tricho
fb_tricho tom_micro cab_micro fb_micro tom_bio cab_bio fb_bio
```

Table 4.6

```
tab1 tom_severeins tom_severedis cab_severeins cab_severedis fb_severeins fb_severedis
dveg_insstrs dveg_disstrs
```

Table 4.7

```
oprobit ycategory dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit
i.cementortile c.acresowned##c.acresowned livestock ///

i.dmember i.sorexten i.dgender1 c.centipmveg##c.centipmveg i.b4.county if no_veg>0, vce
(cluster code_ward)
```

```
est store adopveg

margins, dydx(*) predict (outcome(1)) post
est store adopveg1

est restore adopveg
margins, dydx(*) predict (outcome(2)) post
est store adopveg2

est restore adopveg
margins, dydx(*) predict (outcome(3)) post
est  store adopveg3

est table adopveg1 adopveg2 adopveg3, p
```

Table 4.8

```
oprobit ytomato dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock ///
i.dmember i.sorexten i.dgender1 c.centipmtom##c.centipmtom i.b4.county if tom_yesno==1, vce (cluster code_ward)

est store adoptom

margins, dydx(*) predict (outcome(1)) post
est store adoptom1
est restore adoptom
margins, dydx(*) predict (outcome(2)) post
est store adoptom2
est restore adoptom
margins, dydx(*) predict (outcome(3)) post
```

est store adoptom3

est table adoptom1 adoptom2 adoptom3, p

Table 4.9

oprobit ycabbage dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock ///

i.dmember i.sorexten i.dgender1 c.centipmcab##c.centipmcab i.b4.county if cab_yesno==1, vce (cluster code_ward)

est store adopcab

margins, dydx(*) predict (outcome(1)) post

est store adopcab1

est restore adopcab

margins, dydx(*) predict (outcome(2)) post

est store adopcab2

est restore adopcab

margins, dydx(*) predict (outcome(3)) post

est store adopcab3

est table adopcab1 adopcab2 adopcab3, p

Table 4.10

probit resistant dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock i.dmember i.sorexten i.dgender1 ///

c.centipmtom##c.centipmtom i.b4.county if tom_yesno==1, vce (cluster code_ward)

est store adoptomres

margins, dydx(*) post

est store adoptomresdydx

probit staking dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock i.dmember i.sorexten i.dgender1 ///

c.centipmtom##c.centipmtom i.b4.county if tom_yesno==1, vce (cluster code_ward)

est store adoptomstk

margins, dydx(*) post

est store adoptomstkdydx

outreg2 [adoptomresdydx adoptomstkdydx] using resiststk.doc, replace dec(3) ctitle(dy/dx)

Table 4.11

probit resistant dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock i.dmember ///

i.sorexten i.dgender1 c.centipmcab##c.centipmcab i.b4.county if cab_yesno==1, vce (cluster code_ward)

est store adopcabres

margins, dydx(*) post

est store adopcabresdydx

probit nets dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock i.dmember ///

i.sorexten i.dgender1 c.centipmcab##c.centipmcab i.b4.county if cab_yesno==1, vce (cluster code_ward)

est store adopcabnets

margins, dydx(*) post

est store adopcabnetsdydx

outreg2 [adopcabresdydx adopcabnetsdydx] using cabresnet.doc, replace dec(3) ctitle(dydx)

Table 4.12

reg applyveg_mean dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned ///

livestock i.dmember i.sorexten i.dgender1 c.centipmveg##c.centipmveg i.b3.dveg_disstrs2 i.b3.dveg_insstrs2 i.b4.county if no_veg>0, vce (cluster code_ward)

margins, dydx(*) post

est store app2

reg tom_apply dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock ///

i.dmember i.sorexten i.dgender1 c.centipmtom##c.centipmtom i.b3.tom_severedis2 i.b3.tom_severeins2 i.b4.county if tom_yesno==1, vce (cluster code_ward)

margins, dydx(*) post

est store app3

reg cab_apply dofffarm ageinfo i.education2 workable expveg disttown distinput i.dcredit i.cementortile c.acresowned##c.acresowned livestock ///

i.dmember i.sorexten i.dgender1 c.centipmcab##c.centipmcab i.b3.cab_severedis2 i.b3.cab_severeins2 i.b4.county if cab_yesno==1, vce (cluster code_ward)

margins, dydx(*) post

est store app4

est table app2 app3 app4, p

Appendix B: Questionnaire

IPM Innovation Lab Kenya

Interview Questionnaire

2016

ALL INFORMATION CONTAINED IN THIS QUESTIONNAIRE IS STRICTLY

CONFIDENTIAL

SECTION 1: METADATA

	NAME	CODE
INTID: ENUMERATOR ID		[__|__|__]
REGION: NAME AND CODE OF REGION		[__|__|__]
COUNTY: NAME AND CODE OF COUNTY		[__|__|__]
SUB-C.: NAME AND CODE OF SUB-COUNTY		[__|__|__]
LOCATION: NAME AND CODE OF WARD		[__|__|__]
VILLAGE: NAME AND CODE OF VILLAGE		[__|__|__]
HHID: NAME OF HOUSEHOLD HEAD		

1. INTERVIEW DATE AND TIME	[__|__][__|__] 2016 **DAY/MONTH/YEAR**
2. TIME INTERVIEW STARTED	[__|__][__|__] **HH MM**
3. TIME INTERVIEW FINISHED	**[__|__][__|__]**
	HH MM
4. RESULT (SEE LIST BELOW)	**[__]**
RESULT 1 = COMPLETE 2 = NOT COMPLETE (RETURN TO HOUSEHOLD) 3 = NOT AVAILABLE 4 = REJECTION 5=COULD NOT LOCATE HOUSEHOLD 99 = OTHER (SPECIFY)________________________________	
QUALITY CONTROL	
5. DATE, INTERVIEW SUPERVISOR	[__|__][__|__] [__|__|__|__]
	DAY MONTH YEAR
6. RESULT, SUPERVISOR (CIRCLE ANSWER)	1 = COMPLETE (SEND TO VA TECH) 2 = NOT COMPLETE (RETURN TO HOUSEHOLD) 3 = NOT AVAILABLE

	4 = REJECTION 5=COULD NOT LOCATE HOUSEHOLD 99 = OTHER (SPECIFY)

SECTION 2: LOCATING HOUSEHOLD AND OBTAINING CONSENT

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: YOUR FIRST JOB IS TO LOCATE THE HOUSEHOLD AND FARMER THAT WAS IDENTIFIED IN THE LIST TO BE INTERVIEWED. YOUR SECOND JOB IS TO ASCERTAIN WHO IN THE HOUSHOLD HAS MOST INFORMATION WITH RESPECT TO MAIZE AND VEGETABLE PRODUCTION. IN MALE HEADED HOUSEHOLDS, INTERVIEW BOTH SPOUSES JOIUNTLY IF POSSIBLE. YOUR THIRD TASK IS TO OBTAIN CONSENT FOR THE INTERVIEW. IF YOU CANNOT FIND THE HOUSEHOLD OR THE FARMER IS NO LONGER IN THE VILLAGE, NOTE THE REASON WHY . THESE QUESTIONS WILL HELP TO DETERMINE WITH WHOM (OR IF) THE INTERVIEW WILL BE CONDUCTED.			
1	**WERE YOU ABLE TO LOCATE THE HOUSE?**	No……………………..………………………………………0 Yes……………………..……………………………………..1	**->Q9** **>Q2**
2	Please write down the correct **latitude of the housed.**	**[USE GPS DEVICE]: ________________________**	
3	Please write down the correct **longitude of the house.**	**[USE GPS DEVICE]: ________________________**	
4	Who has the most information on crop production in your household?	Mostly Myself ……….……………….…………………..1 Mostly My Spouse……………………………………….2 Myself and My Spouse Equally…..……………..………3 Other (Specify)__________________________....99 No one…………………………………………………5	 **>STOP**
INTERVIEWER: READ THE FOLLOWING STATEMENT TO THE FARMER: "WE ARE CONDUCTING A SURVEY OF MAIZE AND VEGETABLE PEST PROBLEMS AND PEST MANAGEMENT PRACTICES IN YOUR VILLAGE AS PART OF A PROJECT AIMED AT REDUCING THOSE PEST PROBLEMS. THIS SURVEY PROJECT INVOLVES VIRGINIA TECH UNIVERSITY IN THE UNITED STATES AND KALRO AND ICIPE IN KENYA. THIS SURVEY WILL TAKE ABOUT AN HOUR. RESPONDING TO QUESTIONS ON THIS SURVEY IS VOLUNTARY. IF YOU AGREE TO RESPOND, YOUR ANSWERS WILL REMAIN CONFIDENTIAL. DO YOU CONSENT TO RESPOND?"			
5	**DOES THE FARMER (HE/SHE) CONSENT TO BEING INTERVIEWED?**	No, rejects interview……..……………………………………0 Yes, accepts interview………..…………………………….1 **(THANK THE FARMER FOR AGREEING TO PARTICIPATE)**	**-> STOP** **>Q6**
6	**NAME OF THE FARMER BEING INTERVIEWED**	**(WRITE DOWN NAME(S)):**______________________	**>SEC3**
7	**INDICATE WHETHER ONE OR BOTH SOUSES WERE INTERVIEWED**	**MAN…………………………………………………………..1** **WOMAN……………………………………………………….2** **BOTH………………………………………………………….3**	

No	QUESTIONS	CODES/RESPONSES	GO TO
8	**DID THE FARMER GROW MAIZE OR VEGETABLES IN THE PAST 12 MONTHS?**	No...0 Yes...1	**-> STOP** **>SEC3**
9	**IF YOU CANNOT LOCATE THE FARMER, WHY?**	Temporarily gone for the day/week/month.……………...1 Left village (migrated)………………………….……… 2 Community leaders never heard of the farmer…..……...3 Other (Specify)___________________……………….. 99	

SECTION 3: DEMOGRAPHIC INFORMATION

No	QUESTIONS	CODES/RESPONSES	GO TO
[INTERVIEWER: SAY TO THE FARMER: I WOULD FIRST LIKE TO ASK YOU QUESTIONS ABOUT YOURSELF AND YOUR FAMILY.			
1	**Do you have a phone?**	No…………….. ………..………………………………0 Yes ………..…………………………………..1	**->Q3** **>Q2**
2	**What is your phone number?**	Phone number:_______________________	
3	Sex of the respondent? **[MAY NOT NEED TO ASK]**	Male………………..………………………………………1 Female…………………..…………………………………2	
4	What is your age?	[___|___] Years	
5	What is your marital status?	Married (legal or not) ……………………………………1 Single or never married…………………………….….2 Widow/widower……………………………….…….3 Separated/Divorced…….………………………………..4 Other……………………………………………………..99	**>Q6** **->Q7** **->Q7** **->Q7** **->Q7**
6	What is your spouse's age? (**IN POLYGAMOUS HOUSEHOLD ASK AGE OF PRIMARY SPOUSE)**	[___|___] Years	
7	What is your primary occupation?	Agriculture (any type)………………………………….…1 Business……………..……………………………….....2 Wage Job……………..……………………………….....3 Other (specify).____________________________..99	
8	What is your secondary occupation? **[NOTE SECONDARY OCCUPATION CANNOT BE SAME AS PRIMARY]**	Agriculture…….………………………………………..…1 Business………..……………….…………………….....2 Wage Job……………..………………………………..…..3 Other (specify).____________________________...99 No secondary occupation…..………………….……4	

No	QUESTIONS	CODES/RESPONSES	GO TO
9	Have you ever attended school?	No……………………..………………………………………0 Yes…………………..……………………………………..1	**->Q11** **>Q10**
10	How many total years of schooling have you completed?	[___|___] Years	
11	Can you read?	No……………………..………………………………………0 Yes…………………..……………………………………..1	
12	Can you write?	No……………………..………………………………………0 Yes…………………..……………………………………..1	
13	How many years of experience do you have in vegetable cultivation?	[___|___] Years	
	How many family members live in your house (live under same roof)?		
14	….Number of male members?	[___|___]	
15	…Number of female members?	[___|___]	
16	How many of these family members work or are able to work? **(Q16 CANNOT BE GREATER THAN Q14 AND Q15)**	[___|___]	
17	Has the farmer's spouse ever attended school? **(IF MARRIED)**	No……………………..………………………………………0 Yes…………………..……………………………………..1	**->Q19** **>Q18**
18	How many years of schooling has the farmer's spouse completed **(IF MARRIED)**?	[___|___] Years (1-12)	
19	Can the farmer's spouse read? **(IF MARRIED)**	No………………..…………………………………………0 Yes…………………..……………………………………..1 Does not know....……….………………………………88	
20	Can the farmer's spouse write? **(IF MARRIED)**	No………………..…………………………………………0 Yes…………………..……………………………………..1 Does not know....……….………………………………88	
21	Over the past year, how many months could you feed your family with only your household income and agricultural production?	[___|___] Months (0-12)	
22	How far is your farm from the nearest market?	[___|___]___| KM	
23	How far is your house from the nearest agricultural extension office?	[___|___]___| KM	

No	QUESTIONS	CODES/RESPONSES	GO TO
24	How far is your house from the nearest agricultural input (seed, pesticide) dealer/store?	[___|___]___| KM	
25	How far is your village from the county town/city?	[___|___]___| Kilometers	
26	Did you borrow to finance your crop production last year?	No……………….………………………………………0 Yes…………………..…………………………………..1	->SEC 4 >Q27
27	Was your household ab le to borrow the amount it needed?	No……………….………………………………………0 Yes…………………..…………………………………..1	

SECTION 4: HOUSEHOLD ASSETS

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT YOUR HOUSE			
1	What is the primary material for the walls of your house?	Simple Clay or mud……..………..………………………………1 Bamboo/Straw………………..…………………………………..2 Bricks/Stone…………………..…………………………………..3 Wood/Iron Sheet…………………………………………………..4 Other (specify)....….………….…………………………………99	
2	What is the primary material for the roof of your house:	Straw/palm tree leaves……………………………………..………1 Iron Sheet..………..…………………………………….………..2 Brick/Concrete…………………..………………………………..3 Other (specify)....….…………..……………….………………99	
3	What is the primary material for the floor of your house?	Earth………………………………..………………………..………1 Cement……………..……………………………………..………..2 Tile……………..…………………..………………………………..3 Wood……………………………………………………………….4 Other (specify)_________________________________…99	
4	Do you have electricity in your home?	No………………………..…………………………………………0 Yes…………………………..……………………………………..1	
5	How many rooms does your house have? [**NUMBER MUST BE GREATER THAN 0]**	[___|___] **Number of rooms**	
6	Do you rent or own the house you live in?	Rent………………..………………………………………1 Own….……………..….………………………………..2 Other (specify)....……..…………………..………………99	

No	QUESTIONS	CODES/RESPONSES	GO TO
7	**How much land (in acres) does your household own?** (**CHANGE UNITS IF NECESSARY TO UNITS PER ACRE**)	[___|___].[___|___] **IF NONE WRITE 0**	
8	How many livestock do you own?	a. Cattle (Number)……………………………… [___|___] b. Plowing Oxen (Number)….…………………………………...[___|___] c. Goats/Sheep (Number)……………………… [___|___] d. Donkey/mule (number)………………………. [___|___] e. Pig (number)…………………………………... [___|___]	

SECTION 5: LAND USAGE

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT THE LAND YOU ARE FARMING.			
	How much of the land (in acres) that you and your household members **FARMED LAST YEAR…**		
1	How many acres of land that you and your family members currently farm?	[___|___].[___|___] **IF NONE WRITE 0**	
2	…..is owned by the household with title?	[___|___].[___|___] **IF NONE WRITE 0**	
3	…..is owned by the household without title?	[___|___].[___|___] **IF NONE WRITE 0**	
4	…. is rented in or sharecropped?	[___|___].[___|___] **IF NONE WRITE 0**	
5	…is rented out?	[___|___].[___|___] **IF NONE WRITE 0**	
6	…is public land?	[___|___].[___|___] **IF NONE WRITE 0**	
7	….is farmed by other means?	[___|___].[___|___] **IF NONE WRITE 0**	
99	Specify the type of other means	______________________________	

SECTION 6: ORGANIZATION OR GROUP MEMBERSHIP

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT THE ORGANIZATIONS AND GROUPS YOU BELONG TO.			
1	Are you or your spouse a member of any farm or community organization?	Self a member……………..………………………………………1 Spouse a member……………..……………………………..…...2 Neither a member…………………………………………..…..3 Both Members……………………………………………………..4	**->Section7**
2	Are you or your spouse a member of savings group?	Self a member……………..………………………………………1 Spouse a member……………..……………………………..…...2 Neither a member…………………………………………..…..3 Both Members……………………………………………………..4	
3	Are you or your spouse a member of a marketing cooperative or marketing group?	Self a member……………..………………………………………1 Spouse a member……………..……………………………..…...2 Neither a member…………………………………………..…..3 Both Members……………………………………………………..4	
4	Are you or your spouse a member of a Merry-go-round?	Self a member……………..………………………………………1 Spouse a member……………..……………………………..…...2 Neither a member…………………………………………..…..3 Both Members……………………………………………………..4	
99	Other group? (specify)	Specify the type of other:______________________________	

SECTION 7: AGRICULTURAL KNOWLEDGE SOURCES

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT HOW YOU RECEIVE ADVICE OR LEARN ABOUT AGRICULTURE			
	In the past 12 months, have you received advice and/or learned about agriculture from……**[READ LIST]**		
1	……an Agricultural extension worker (individual visit, field day, farmer field school)?	No…………………..………………………………………0 Yes……………………..…………………………………..1	

No	QUESTIONS	CODES/RESPONSES	GO TO
2	……Relatives?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
3	…….Neighbor or friend?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
4	…….Field Day?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
5	….Farmer Field School?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
6	…….Seed/pesticide/ fertilizer salesperson?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
7	…….Radio?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
8	…….Television?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
9	…..Newspaper/Leaflet?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
10	…….Mobile phone message?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
11	…….Farmers' group?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
12	…….Other means not previously mentioned?	No…………………..…………………………………………0 Yes……………………..………………………………..1	
99	Specify the other	____	

SECTION 8: MAIZE and VEGETABLE PRODUCTION

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT THE MAIZE AND VEGETABLES YOU PRODUCED			
	During the past year how many acres, if any, did you plant of …. **[READ THE LIST. IF DID NOT GROW, WRITE 0]**		
1	Maize	[___|___].[___|___]	
2	Tomato	[___|___].[___|___]	
3	Cabbage	[___|___].[___|___]	

No	QUESTIONS	CODES/RESPONSES	GO TO
4	French Beans	[___|___].[___|___]	
5	Chili pepper	[___|___].[___|___]	
6	Onion	[___|___].[___|___]	
7	During the past year how many bags (90 kgs.) of maize did you produce? **IF DID NOT GROW, WRITE 0]**	[___|___]___|___]	
	During the past 12 months what was the total value of the Maize and vegetables you sold (in KSH)? ………. [**READ THE LIST. IF DID NOT GROW, WRITE 0]**		
8	Maize	[___|___]___|___]___|___]	
9	Tomato	[___|___]___|___]___|___]	
10	Cabbage	[___|___]___|___]___|___]	
11	French Beans	[___|___]___|___]___|___]	
12	Chili Pepper	[___|___]___|___]___|___]	
13	Onion	[___|___]___|___]___|___]	
14	What percent of your Maize production do you consume in your household? **(USE 10 MAIZE GRAINS TO OBTAIN PERCENTAGE)**	[___|___]___| Percent	
15	If you sold Maize, to whom did you sell it (**Circle all that apply**) ,	Local trader…………………………………1 Non-local trader…………………………….2 Cooperative…………………………………3 Sold it myself (or my family) in Market.…..4 Other (Specify)________________……….99	
16	What percent of your family's income is from selling maize?	[___|___]___| Percent	
17	What percent of your vegetable production do you consume in your household?	[___|___]___| Percent	
18	If you sold vegetables, to whom did you sell them (**CIrcle all that apply**) ,	Local trader…………………………………1 Non-local trader…………………………….2 Cooperative or marketing group….………3 Sold by myself (or my family) in Market…..4 Other (Specify)…………………………….99	
19	What percent of your family's income is from selling vegetables?	[___|___]___| Percent	
20	What type of water system do you use for your vegetable production?	Irrigation system…..…………………………1 Water with cans or buckets………………..2	

No	QUESTIONS	CODES/RESPONSES	GO TO
		Rainfed……………………………………3	

SECTION 9: PESTS and PEST MANAGEMENT OF MAIZE and VEGETABLE CROPS

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT YOUR MAIZE AND VEGETABLE PESTS AND PEST MANAGEMENT LAST YEAR.			
1	**DID YOU GROW MAIZE LAST YEAR?**	No……………………………………………0 Yes……………………………………………..1	**->Q2** **>Q1a**
a	What are the major insect/worm, disease/virus, and weeds that affect your maize plants? (**SHOW PICTURES and CIRCLE ALL THAT APPLY**)	Stem borer ……………………………………1 Rust ……………………………………………2 Maize streak virus……………………………3 Leaf blights……………………………………4 Stem and root rots………………………………5 Striga……………………………………………..6 Termite…………………………………………..7 Other, specify …………………………………99	
b	How severe were your maize insect/worm pests last year?	None……………………………………………0 Low……………………………………………..1 Medium…………………………………………2 High……………………………………………3	
c	What was your **worst** maize insect/worm pest last year?	Specify (if known):_______________________	
d	How severe were your maize diseases/viruses last year?	None……………………………………………0 Low……………………………………………..1 Medium…………………………………………2 High……………………………………………..3	
e	What was your **worst** maize disease/virus last year?	Specify (if known):_______________________	
f	Which type of pest caused the most damage to your maize crop last year (**CIRCLE ONE**)?	Insects/worms……………………………………1 Diseases/viruses………………………………..2 Weeds…………………………………………….3 Birds……………………………………………..4	
g	How many times did you, someone in your family, or someone you hired apply pesticides (insecticides, fungicides, herbicides, etc.) to your maize during the last maize season?	[___|___] Total Number of applications	**IF 0 GO TO 1j**

No	QUESTIONS	CODES/RESPONSES	GO TO
h	How much did you spend on pesticides for maize during the last maize season?	[___|___].[___|___] (KSH)	
I	How many hours were used to apply pesticide to Mize last season? (Sum total hour spent by each individual)	[___|___].[___|___]	
J	How many person-days were used to apply pesticides to maize last season?	[___|___] Number of person-days	
K	How many person-days were used to weed your maize last season?	[___|___] Number of person-days	
L	Who does your weeding of maize? **(CIRCLE ALL THAT APPLY)**	Mostly Myself ……………………………………………..1 Mostly My Spouse (s)..………………………………2 Myself and My Spouse (s) Equally….………………3 Children and other family members…………………4 Hired labor……………………………………………..5 Others…………………………………………………6 No one…………………………………………………7	
M	Which of the following non-pesticide practices, if any, did you use to control maize insect and disease pests? **(CIRCLE ALL THAT APPLY)**	Pest-resistant variety………………………..…………1 Push-Pull technology for stem borer control…..…2 Apply microbial pesticide (e.g., Metarhizium sp. and Beauveria sp.)……………………………..……..3 Apply bio-pesticide such as neem........................4 Remove and bury infected plants…………………5 Crop rotation…………………………………………6 Maize grain legume intercropping…………………………………………7 Other (Specify)……………………………………99 None…………………………………………………0	
N	Why did you use a non-pesticide or minimal-pesticide practice (if any)? **(CIRCLE ALL THAT APPLY)**	Cost less than pesticides…………………………....1 More effective than pesticides…………….……...2 Safer for my own or my family's health………..….3 Better for the environment (water, soil, birds, etc.)..4 Protects beneficial insects …………………………..5 Other (Specify)____________________.................99	
2	**DID YOU GROW TOMATOES LAST YEAR?**	No……….………………………………..………0 Yes……………..…………………………………..1	**->Q3** **>Q2a**

No	QUESTIONS	CODES/RESPONSES	GO TO
	What are the major insect/worm and disease/virus pests that affect your tomatoes? (SHOW PICTURES and CIRCLE ALL THAT APPPLY)	Spider mites..…………………..…………………..1 Leaf miners.……………….…………………………2 White flies…………………………………………….3 Bacterial wilt……..……….………………………….7 Nematodes…….. ..……………………………….10 Other, specify _______________…………………99	
A	How severe were your tomato insect/worm pests last year?	None…………………………………………………0 Low……………………………………………….…..1 Medium………………………………………………2 High……..……………………………………………3	
B	What was your worst tomato insect/worm pest last year?	ecify (if known):_________________________	
C	How severe were your tomato disease pests last year?	None…………………………………………………0 Low……………………………………………….…..1 Medium………………………………………………2 High………………………………………………..3	
D	What was your worst tomato disease/virus last year?	Specify (if known):_________________________	
E	Which type of pest caused the most damage to your tomato crop last year (**CIRCLE ONE**)?	Insects/worms……………………….………………1 Diseases/Viruses.…………………………………….2 Weeds…………………………………………………3	
F	(insecticides, fungicides, herbicides, etc.) to your tomatoes during the last tomato season?	[___|___] Total Number of Applications	
G	How much did you spend on pesticides during the last tomato season?	[___|___].[___|___] (KSH)	**IF 0 GO TO 2j**
H	How many total hours were used to apply pesticides to tomatoes last season?	[___|___] Number of person-days	
I	Have you or anyone oin your family become ill after applying pesticide to tomatoes?	No………..……………………………..………0 Yes…………….……………………………………..1	
	How many total hours were used to weed your tomatoes last season?	[___|___] Number of person-days	

No	QUESTIONS	CODES/RESPONSES	GO TO
J	Who does your weeding of tomato? **(CIRCLE ALL THAT APPLY)**	Mostly Myself ……………………………………..1 Mostly My Spouse…………………………………..2 Myself and My Spouse Equally………………………3 Children and other family members………………..4 Hired labor…………………………………………..5 Others…………………………………………………6 No one…………………………………………………7	
K	Which of the following non-pesticide practices, if any, did you use to control tomato insect and disease pests? **(CIRCLE ALL THAT APPLY)**	Pest-resistant variety………………………………1 Select healthy seeds/sanitizing seed treatment…2 Raise seedlings in trays with sterilized soil……….3 Use nursery nets to exclude insects……………….4 Apply Trichoderma on seeds, seedlings, or soil....5 Staking of plants……………………………………6 Remove damaged plants………………………….. 7 Hang pheromone trap……………………………….8 Hang yellow sticky traps ……………………………9 Apply microbial pesticide such as *Bt……………..10* Apply bio-pesticide such as neem.........................11 Other…………………………………………………99 None…………………………………………………0	
L	Why did you use a non-pesticide or minimal-pesticide practice (if any)? **(CIRCLE ALL THAT APPLY)**	Cost less than pesticides…………………………....1 More effective than pesticides……………………...2 Safer for my own or my family's health…………..…3 Better for the environment (water, soil, birds, etc.)..4 Protects beneficial insects ………………………….5 Other (Specify)____________________.................99	
M	In what season(s) did you grow tomatoes last year? (**CIRCLE ALL THAT APPLY**)	Wet season…………………………………………1 Dry season…………………………………………..2	
N	**DID THE FARMER GROW CABBAGE LAST YEAR?**	No…………..……………………………………..……0 Yes………………..………………………………….1	
3	What are the major insect/worm and disease/virus pests that affect your cabbage? (**SHOW PICTURES and CIRCLE ALL THAT APPPLY**)	Diamondback moth………..………………………..1 Aphids……..…………….……………………………2 Black rot………………………………………………3 Club root…..………………………………………..4 Other, specify ________________…d………………99	**->Q4** **>Q3a**

No	QUESTIONS	CODES/RESPONSES	GO TO
A	How severe were your cabbage insect/worm pests last year?	None……………………………………………0 Low……………………………………………..1 Medium………………………………………2 High……………………………………………3	
B	What was your **worst** cabbage insect/worm pest last year?	Specify (if known):_______________________	
C	How severe were your cabbage diseases last year?	None……………………………………………0 Low……………………………………………..1 Medium………………………………………2 High……………………………………………..3	
D	What was your **worst** cabbage disease last year?	Specify (if known):_______________________	
E	Which type of pest caused the most damage to your cabbage crop last year (**CIRCLE ONE**)?	Insects/worms…………………………………1 Diseases/Viruses……………………………2 Weeds…………………………………………3	
F	How many times did you, someone in your family, or someone you hired apply pesticides (insecticides, fungicides, herbicides, etc.) to your cabbage during the last cabbage season?	[___|___] Total Number of Applications	
G	How much did you spend on pesticides during the last cabbage season?	[___|___].[___|___] (KSH)	**IF 0 GO TO 3j**
H	How many total person-days were used to apply pesticides to cabbage last season?	[___|___] Number of person-days	
I	How many person-days were used to weed your cabbage last season?	[___|___] Number of person-days	
J	Who does your weeding of cabbage? **(CIRCLE ALL THAT APPLY)**	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………….2 Myself and My Spouse Equally……………………3 Children and other family members………………4 Hired labor…………………………………………..5 Others…………………………………………………6 No one…………………………………………………7	

No	QUESTIONS	CODES/RESPONSES	GO TO
K	Which of the following non-pesticide practices did you use to control cabbage insect and disease pests? **(CIRCLE ALL THAT APPLY)**	Plant pest-resistant variety…………………………1 Select healthy seeds/sanitizing seed treatment …2 Grow seedlings in trays with sterilized soil……….3 Nursery nets to exclude insects……………………4 Apply Trichoderma on seeds, seedlings, or soil.….5 Remove damaged plants………………………….. 6 Hang pheromone trap……………………………… 7 Hang yellow sticky trap……………………………..8 Apply bio-pesticide such as neem..………….........9 Apply microbial pesticides such as Bt…………….10 Other…………………………………………………99 None………………………………………………….0	
L	Why did you use a non-pesticide or minimal-pesticide practice (if any)? **(CIRCLE ALL THAT APPLY)**	Cost less than pesticides………………………….…1 More effective than pesticides………………….……..2 Safer for my own or my family's health………..….3 Better for the environment (water, soil, birds, etc.)..4 Protects beneficial insects …………………………..5 Other (Specify)______________________..........99	
M	In what season did you grow cabbage last year?	Wet season………………………………………1 Dry season………………………………………..2	
N	**DID THE FARMER GROW FRENCH BEANS LAST YEAR?**	No………..……………………………………..……0 Yes………………..………………………………..1	
4	What are the major insect/worm and disease/virus pests that affect your French Beans? (**SHOW PICTURES and CIRCLE ALL THAT APPPLY**)	Bean Fly…………………….……………………….1 White Fly…...……………….……………………………2 Pod Borer…..…………………………………………3 Rust……………..………..…………………………4 Other, specify ______________…………………99	**->5** **>Q4a**
A	How severe were your bean insect or worm pests last year?	None…………………………………………………0 Low…………………………………………………..1 Medium………………………………………………2 High…….……………………………………………3	
B	What was your **worst** insect or worm pest of beans last year?	Specify (if known):________________________	
C	How severe were your bean diseases/viruses last year?	None…………………………………………………0 Low…………………………………………………..1 Medium………………………………………………2 High…………………………………………………..3	
D	What was your **worst** disease/virus of beans last year?	Specify (if known):________________________	

No	QUESTIONS	CODES/RESPONSES	GO TO
E	Which type of pest caused the most damage to your bean crop last year (**CIRCLE ONE**)?	Insects/worms..………………….………………….1 Diseases/Viruses.…………………………………2 Weeds……………………………………………….3	
F	How many times did you, someone in your family, or someone you hired apply pesticides (insecticides, fungicides, herbicides, etc.) to your beans during the last bean season?	[___|___] Total Number of Applications	
G	How much did you spend on pesticides during the last bean season?	[___|___].[___|___] (KSH)	**IF 0 GO TO Q4j**
H	How many total person-days were used to apply pesticides to beans last season?	[___|___] Number of person-days	
I	How many person-days were used to weed your French Beans last season?	[___|___] Number of person-days	
J	Have you or anyone in your family ever become ill from applying pesticides to French beans?		
k	Who does your weeding of French Beans? **(CIRCLE ALL THAT APPLY)**	Mostly Myself ……….……………….…………………..1 Mostly My Spouse…………………………………..2 Myself and My Spouse Equally….………….….……3 Children and other family members………..….…4 Hired labor…………………………………………..5 Others…………………………………………………6 No one…………………………………………………7	
L	Which of the following non-pesticide practices did you use to control bean insect and disease pests? **(CIRCLE ALL THAT APPLY)**	Pest-resistant variety……………………….…………1 Select healthy seeds/sanitizing seed treatment….2 Apply Trichoderma on seeds, seedlings, or soil....3 Remove damaged plants………………………… 4 Hang pheromone trap………………………………5 Hang yellow sticky traps ……………………….…..6 Apply microbial pesticide such as *Bt………….….7* Apply bio-pesticide such as neem.........................8 Other…………………………………………………99 None…………………………………………….……0	
M	Why did you use a non-pesticide or minimal-pesticide practice (if any)? **(CIRCLE ALL THAT APPLY)**	Cost less than pesticides…………………………....1 More effective than pesticides……………….……..2 Safer for my own or my family’s health………..….3 Better for the environment (water, soil, birds, etc.)..4	

No	QUESTIONS	CODES/RESPONSES	GO TO
		Protects beneficial insects …………………………..5 Other (Specify)__________________..................99	
N	In what season did you grow French beans last year? (**CIRCLE ALL THAT APPLY**)	Wet season………………………………………1 Dry season………………………………………..2	
O			

SECTION 10: IPM TRAINING

No	QUESTIONS	CODES/RESPONSES	GO TO
[INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT THE TYPE OF TRAINING YOU HAVE RECEIVED ON IPM AND PESTICIDE USE			
1	Have you received any training related to IPM?	No………..……………………………………0 Yes……………..……………………………….1	**->SEC11** **>Q2**
2	If yes, how many times have you received IPM training?	[___|___]	
3	From whom did you receive training? [**READ LIST BELOW]**		
A	……KALRO or KARI (Kenyan Agricultural and Livestock Research Organization)	No………..………………..……………………0 Yes……………..……………………………….1	
B	……NALEP (National Agricultural and Livestock Extension Programme)	No………..……………………………………0 Yes……………..……………………………….1	
C	……IPM club or group	No………..……………………………………0 Yes……………..……………………………….1	
D	……NGO	No………..……………………………………0 Yes……………..……………………………….1	
E	……Real IPM	No………..……………………………………0 Yes……………..……………………………….1	
F	…….University		
G	……Other	No………..……………………………………0 Yes……………..……………………………….1	**->next**
H	Specify the other	____________________________________	

SECTION 11: GENDER and IPM

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER: SAY TO THE FARMER: NOW I WOULD LIKE TO ASK YOU A FEW QUESTIONS ABOUT PEST MANAGEMENT DECISION MAKING ON YOUR FARM			
1	Who buys pesticides or other pest management products?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Other household members…………………………..4 Others…………………………………………………5 No one…………………………………………………6	
2	Who decides how much to spend on pesticides or other pest management products?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Other household members…………………………..4 Others…………………………………………………5 No one…………………………………………………6	
3	Who applies pesticides or other pest management products when needed?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Other household members…………………………..4 Hired labor……………………………………………..5 Others…………………………………………………6 No one…………………………………………………7	
4	When pest problems occur, who in your family decides what to do?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Others…………………………………………………4 No one…………………………………………………5	
5	When money is earned from selling maize, who in your family decides how it is spent?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Others…………………………………………………4 No one…………………………………………………5	
6	When money is earned from selling vegetables, who in your family decides how it is spent?	Mostly Myself ……………………………………..1 Mostly My Spouse……………………………………2 Myself and My Spouse Equally………………………3 Others…………………………………………………4 No one…………………………………………………5	

SECTION 12: PESTICIDE USE

No	QUESTIONS	CODES/RESPONSES	GO TO
INTERVIEWER SAYS TO THE FARMER: NOW I WOULD LIKE TO ASK YOU A FEW MORE QUESTIONS RELATED TO YOUR USE OF PESTICIDES ON VEGETABLES			
1	Have you or anyone in your family ever become ill from applying pesticides?	No…………………………………………….…0 Yes………………………..……………………...1	
2	How effective were the pesticides you applied during the past year?	Effective………………………………………………1 Not effective…………………………………….…..2 Don't know……………………………………………3 Did not apply pesticides…………………………….4	
	If not effective, what measures did you take?	Increase Concentration…………………………….1 Increase Frequency ………………………………...2 Other Measures ……………………………………..3 Other measures………………………………………4 ____ ____	
3	How do you decide **when** to apply pesticides? (**CIRCLE ALL THAT APPLY**)	Read label on pesticide container…………………..1 Advice from pesticide dealer…………………………2 Advice from extension agent…………………………3 Advice from relative or friend…..……………………..4 Growth stage of plant…………………………………5 Spray at regular or fixed intervals……………….…..6 Based on number of pests……………………………7 Based on visible damage…………………………….8 Other (Specify)__________________________.....99 Do not use pesticides…………….…………………9	
4	What clothes or gear do you wear while applying pesticides? (**CIRCLE ALL THAT APPLY**)	Short sleeve top………………………………………1 Long sleeve top………………………………………..2 Short pants……………………………………………3 Long pants……………………………………………..4 Shoes……………………………………………….…..5 Sandals…………………………………………….….6 Rubber/gum boots………..……………………….…..7 Hat……………………………………………………….8 Mask or goggles……..………………………………9 Other (Specify)……………………………………….99.	
5	Are their insects that do not cause damage to your crops, but actually benefit them?	No……………………………………………..………..1 Yes……………………………………………………..2 Don't know……………………………………………3	
6	Do you agree that killing insects that benefit your crops can increase pest infestation?	Agree…………………………………………………..1 Disagree………………………………………………2 Don't know……………………………………………3	**->Stop** **>Q7**

No	QUESTIONS	CODES/RESPONSES	GO TO
7	Do you think pesticides have adverse effects on the environment?	No……………………………………………..………..1 Yes……………………………………………………..2 Don't know…………………………………………3	
8	If yes, name the effects that you are aware of	Water pollution…………………………………………1 Kill pest's natural enemies……………………………2 Kill beneficial insects such as bees………………….3 Other (Specify)…………………………………………4	**->Stop** **>Q9** ->Stop

Thank you for your time!